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INDEX TO VOLUME XVI

GENERAL ALPHABETICAL INDEX

Entries from the Synopsis of Periodical Literature are indicated by S. (Synopsis); from the analysis of Current Electrochemical, Chemical and Metallurgical United States Patents by P. (Patents).

A

Abrasive. Artificial. Williams.....	599
Acetone and methyl alcohol. From soda pulp industry. White and Rue.....	182
Acetone. By-product from soda pulp industry. Lawrence.....	416
Acids. Transportation by water. Morris. (S.).....	227
Acid-resisting alloys. Kowalke.....	581
Aetna Explosives Co., oil cracking.....	657
Ainsworth, Wm.....	167
Air drying. Hering.....	187
Air drying. Correction. Hering.....	360
Air Reduction Co.....	164
Alcohol. And acetone from soda pulp industry. White and Rue.....	182
—From calcium carbide.....	366
—From molasses. Osborn.....	438
—Methyl. From soda pulp industry. Lawrence.....	416
—Report of U. S. Industrial Co.....	356
Alkali industry in France.....	327
Allison, S. E.....	457

ALLOYS:

—Acid-resisting. Kowalke.....	581
—Aluminum-calcium. Cooper. (P.).....	707
—Arsenic-antimony.....	449
—Bibliography. Estes.....	273
—Bibliography of. Comment on. Anderson.....	360
—Chromium-copper-nickel. (S.).....	608
—Cohalt. Non-corrosive. Kalmus.....	306
—Die-casting copper alloy.....	55
—Electric furnace for melting. Gillet and Lohr. (P.).....	53
—Manganese with brass and bronze. Goldschmidt. (P.).....	400
—Melting of. (S.).....	530
—Nickel-chrome. Brix. (P.).....	228
—Nickel-chromium analysis. Koepfing. Systematic collection of properties by Bureau of Standards.....	365
—Tool-steel. Furness. (P.).....	164
—Zirconium. Cooper. (P.).....	660
Alumina. Bauxite brick.....	210

ALUMINUM:

—Alloys with calcium. Cooper. (P.).....	707
—Canadian production. Demis.....	628
—From aluminum carbide. Herschman. (P.).....	531
—In France.....	328
—Melting aluminum chips. Gillet and James. (S.).....	52
—Production. Haff. Mailloux.....	496
—Production in 1916.....	268
Aluminum. Soldering compound. Stewart.....	660
Aluminum carbide. Production. Barnet. (P.).....	609
Aluminum carbide. (S.).....	530
Aluminum chloride process of benzene and toluene production.....	486
American Association for the Advancement of Science. Symposium on structure of matter.....	72
—Chemical section.....	75
—Committee urges more publicity on research laboratories.....	179
American Ceramic Society. Annual meeting.....	305
American Chemical Society.....	305
—Kansas City meeting. Announcement.....	405
—Program.....	465
—Editorial on.....	423
—Report.....	481
—New York Section: Celebration of twenty-fifth Anniversary.....	308
—New York Section: Meeting.....	677
American Electrochemical Society.....	633
—Buys Liberty Bonds.....	405
—Detroit meeting: Program.....	545
—Editorial on.....	567
—Report.....	567
—New York Section: Announcement of meeting.....	71

American Electrochemical Society—Continued

—New York Section. Symposium on New York Mining Engineers on smelter smoke and fume problem.....	128
—Niagara Falls Section: Officers.....	335
American Gear Manufacturers' Association. Report of convention.....	640
American Institute of Chemical Engineers.....	55
—New York meeting: Program of.....	81
—New York meeting: Report of.....	149
—Program of Buffalo meeting.....	640
American Institute of Mining Engineers.....	127
—New York Meeting Program.....	248
—Report.....	554
—St. Louis meeting. Zinc plants in district.....	772
—Southeast Missouri mills.....	16
—Chicago Section meeting.....	128
—Colorado Section: Meeting report.....	335
—Columbia Section: Meeting of.....	308
—New York Section: Opportunities for American capital in foreign fields.....	71
—New York Section: Announcement of meeting.....	676
—War problem meeting.....	86
—Utah Section meeting.....	629
American Iron and Steel Institute. Report of annual meeting.....	190
American Mineral Production Co.....	628
American Physical Society. Meeting with A. A. S.....	199
American Society for Testing Materials. Program of annual meeting.....	373
American Smelting and Refining Co. Work on smoke abatement.....	300
Ammonium sulphate. From by-product gas producer. Tarr.....	484

ANALYSIS:

—Babbitt metal and journal bearing linings. Koet.....	85
—Babbitt and white metals. Hagmaier.....	84
—Cadmium in brass.....	604
—Glass.....	259
—Light oils. Egloff.....	319
—Nickel chromium alloys. Koepfing.....	487
—Oxygen in manganese ores.....	124
—Phosphorus in high speed steel.....	548
—Rapid filtering. Schleicher.....	71
—Recovery of chinchonine. From solutions used in tungsten analysis. Hagmaier.....	12
—Recovery of molybdic acid from phosphorus filtrates. Hagmaier.....	588
—Rutile. Hagmaier.....	418
—Training the works chemist. Lathe. Vanadium steel. Kraus.....	263
—Zinc. Hastings.....	483
—Zinc.....	454
Annealing. Furnace. Stevens. (P.).....	444
Antimony. Metallurgy. De Cew.....	533
Antimony. Plating.....	81
Apparatus. Chemical engineering. Miles A. R. G. Mining Co. Mill.....	245
Arc. Chemistry of. Mott.....	581
Arc Welding Machine Co. Welding system.....	108
Armour plate plant for West Virginia.....	534
Arsenic. Recovery from fumes. (P.).....	284
Arsenic-antimony alloys.....	449
Asbestos. Hydraulic press.....	45
Asphalt. Nature and origin. Richardson.....	25
Asphalt. Effect of overheating.....	487
Astor, Vincent. Chamber of Commerce dinner. (Ed.).....	123
Astra lead burning apparatus.....	709
Atom. Structure of.....	592
Automobile. Use of grinding wheel.....	617

B

Babbitt metal. Analysis of. Hagmaier.....	85
Babbitt. Analysis. Koet.....	300
Bacon, E. C.....	617

Bag for filtering fume. Cameron (P.)...	284
Ball mills. Being used by gold mining industry.....	5
—Duroloid pebbles.....	356
—Harding.....	417
—Marcy mill. Marcy.....	344
Bancroft, W. D.....	232
Banks, John H.....	405
Barium. Use of barium compounds in desugaring.....	439
Barnard, E. A.....	350
Barstow Management Association.....	296
Bauxite brick.....	210
Bauxite. Shipments from British Columbia.....	624
Bayle, E. J.....	405
Baylis, J. R.....	166
Beckers, Wm.....	36
Beckman, J. W.....	113
Beet molasses. Osborn.....	437
Beets: Sugar from. Benjamin (P.).....	286
Bel, Alexander Graham. Poem on.....	628

BENZENE (Benzol):

—From petroleum. Egloff.....	492
—From coal gas. Corrections to Sperr's paper.....	301
—Recovery from coal gas. Lessing (S.).....	283
—Recovery from gas. Sperr.....	135
—Rittman oil cracking process. Bender (S.).....	657
Berry, George M.....	166
Bethlehem Steel Co., Potash from Blast Furnace.....	205
Birkeland-Eyde nitrogen fixation furnace. Doyle (P.).....	53
Bismuth. Basic salts. Mutscheller.....	594
Bismuth. Exposure.....	486
Black Metal Reduction Co.....	419
Bluestone: Manufacture of. Addicks.....	689
Bogert, M. T.....	711
Boiler Plate. Sodium hydroxide action. Merica.....	497
Boiler settings. Brick used.....	214
Bolivia. Our trade with.....	623

BOOK REVIEWS:

—Anon: Selling your services.....	233
—Jacon and Haimor. The American Petroleum Industry.....	348
—Bond. The Engineer in War.....	167
—Burdick. Chemical Tests for Minerals.....	457
—de Vivaldi-Coaracy: Elementos de Electroquímica.....	167
—Edwards: The Physico-Chemical Properties of Steel.....	167
—Fay: Microscopic examination of steel.....	537
—Handbook of Chemistry and Physics.....	350
—Hansen and Coburn. Diseases of Occupation and Vocational Hygiene.....	167
—Hurley. Awakening of business.....	537
—Johnson. Blast furnace construction in America.....	663
—Lovelace: Annual Chemical Directory of the United States.....	664
—McWane: Pipe and Cast Iron Ware fare.....	233
—Martin and Dancaester. Text Book of Inorganic Chemistry. VIII. The Halogens.....	233
—Mineral Industry 1915. Edited by G. A. Roush.....	233
—Moses and Parsons. Elements of Mineralogy and Petrology.....	457
—Blowpipe Analysis.....	664
—Payne: Founder's Manual.....	233
—Report on the Fertilizer Industry. Federal Trade Commission.....	664
—Russell. Operation of Gas Works.....	711
—Scott. Standard Methods of Chemical Analysis.....	537
—Venable. Radio-activity.....	378
Boulder Tungsten Products Co.....	362
Bramson, C.....	406
Brass: Alloying with manganese. Goldschmidt and Weil (P.).....	400
—Grain size determination on works.....	378
—Influence of arsenic. Smalley (S.).....	607
—Melting. Thornton (S.).....	529

Brazing material. Fuller (P.)	400
Brick: Bauxite	210
—Chromite	210
—Fire clay	210
—Magnesia	209
—Silica. New uses. Gray	209
Brines. Examination	485
Bristol. Automatic temperature controllers	347
Bronze: Alloying with manganese. Goldschmidt and Weil (P.)	400
—Tests on Ampco bronze	510
Brown, E. M.	536
Brown, David H.	415, 423
Budovak and Budovak apparatus	154
Buffalo Mines, Ltd. Annual report	72
Bureau of Standards. Properties of metals and alloys. Study of	365
—Opening of Washington station	165
—Station at Golden, Col.	664
—Work of	111
Bureau of Standards. Properties of metals and alloys. Study of	365
Burrell, Geo. A.	56, 617

C

Cadmium. Metallurgy of. Jurczka-Ralston	146
Calcium. Alloys with aluminum. Cooper (P.)	707
Calcium carbide: Alcohol from	366
Calcium carbide: In France	325
Calcium carbide furnace with by-product recovery	706
Calcium fluoride. Used in potash process	702
California oil fields	454
California. Survey of resources	661
California Trona Company. Case of the Government against	15
Cambridge Glass Co.	296
Campbell, J. A.	457
Canada: Potash from feldspar. Benham (S.)	704
Canadian Pacific Railway. Hydro-electric exhibit	455
Candle industry: Twitchell process. Itiner	144
Carbides. Researches on. Briner (S.)	530
Carbon articles. Manufacture of. Clymer (P.)	659
Carolina, Clinchfield & Ohio R. R. New plants along	364
Carpenter, J.	350
Carrier, C. F., Jr.	406
Carty, J. J.	457
Case-hardening of steel. Stenger	425
Castings. Preparation of iron for Krantz (P.)	107
Cautic alkali manufacture. Ascherof (P.)	107
Cautic soda industry in France	327
Celite. Progress in use of	54
Cells. Use of standard cells. Koerner	45
Celluloid in Japan	456
Cellulose: Electrical treatment. Nodon (P.)	107
Cement Mills. Potash from	657
Cement: Potash from, Riverside plant	701
Cementation of iron and steel. Thum	385
Cementation of steel. Stenger	425
Cements: Plie. Barnett	321
Census of New York City's factories and mercantile houses	632
Census of technical men	422
Centrifugal pump on colloids. Ayres	700
Centrifugal pump. De Lavay	660
Chemical engineering equipment. Development in. Miles	154
Chemical engineer. Training of	421
Chemical industries. Canada. Illustrations	487
—Human side of development. Thompson	149
—Japan. Nishida	505
—Switzerland. Potash from	415
Chemical market. Review of 1916	37
Chemical porcelain. Binus	395
Chemicals: Demand in Spain	239
Chemist. The call for. Moody	641
Chemist. Training the works. Lane	103
Chemists' Club. Annual meeting	566
Chemists' Club Employment Bureau	641
Chewing gum. Chemistry of	486
Chile: Field for capital	478
—Nitrate industry. Hobbs	525
China. Production of salt in Szechuen province	32
Chincholine. Recovery of. Hagaman	70
Chlorine compounds: French manufacture	425
Chlorination. Photochemistry of. Taylor	76
Chrome brick	210
Chromium-copper-nickel alloy (S.)	608
Cincinnati: University of. Dedication of chemical laboratory	4, 1
Cincinnati: University of. New chemistry building	367
Cleaver, C. H.	665
Cline waterpower bill	173
Coal. Action of solvents on. (S.)	282
—Powdered	614
—Recovery of benzol from coal gas. Lessing. (S.)	284
Coal-gas for metal melting. (S.)	530
Cobalt. Addition to very pure commercial iron. Kalmus and Blake	8
Cobalt. Non-corrosive alloy. Kalmus (S.)	706

COKE

—Bee-hive production in 1916	718
—By-product. (Ed.)	68
—Following in low-temperature coking	247
—Increasing use as boiler fuel in England. Note	158
—Necessity for by-product ovens	175
—Recent developments in by-product industry in Japan. Kurahashi	700
—Recovery of benzol from gas. Sperr	135
Coke Ovens. By-product construction	216
—Briek use in beehive ovens	214
—Waste heat from beehive oven industry. Pratt	27
Colloids. Effect of centrifugal force. Ayres	190
—Technological aspect	474
Colorado Scientific Society. 326th meeting	16
Columbia University. Course in laboratory organization	609
Colville. Archibald	167
Concentration. New mills	245
—Colorado tungsten ores. Fischer	559
—Elsol dry concentrator	709
—Graphite, gunpowder, and malt. Wiard	654
—Magnetic separators	632
Condensate cellulose	109
Conder, R. E.	665
Conductivity measurements. Graham	76
Conductors for electric furnaces. Lindstrom	683
Cooling tower for condensing water	710

COPPER:

—Corrosion of tinned copper. Merica (S.)	657
—Exports by countries in 1915 and 1916	544
—Flotation practice in 1916	2
—From mine water	246
—Hydrometallurgical extraction. Weidemann (P.)	227
—Metallurgy of. Schwarz	52
—Operations at Chile. Exploration Co. Rose (S.)	162
—Prospective increase of refining facilities	246
—Refining. Current density. Addicks	311
—Refining. Current efficiency. Addicks	23
—Refining. Impurities in electrolytic refining. Addicks	687
—Impurities in electrolytic refining. Addicks	674
—Refining. Method of connecting electrodes. Whitehead. (P.)	227
—Review of 1916	3
Vaporization of in wirebar furnaces. Butts	85
Wet extraction process. Bradley (P.)	164
Copper sulphate. Manufacture of. Addicks	689
Copper carbide	530
Corporate versus individual effort. Finlay	301
Corrosion of cast iron. Richardson	582
Corrosion. Tinned sheet copper. Merica	657
Cottonseed products industry	624
Cotton. Fumigating	346
Cottrell electrical dust precipitator. Collecting cement dust	702
Cottrell process in practice. Bradley	337
Cottrell precipitation process. Theory. Strong	648
Cottrell, F. G.	648
Couch, James A.	113
Coulter, V. A.	665
Council of National Defense. Personnel of Committees and sub-committees	232
Counter-current decantation. Eames	633
Craver, H. W.	457
Credits. Chemical. Hendrick	126
Crit-point instrument	406
Crook, W. J.	85
Crusher, largest gyratory	286
Cupolas. Brick construction	215
Cuprous oxide photochemical cell	587
Current density in copper refining. Addicks	311
Current efficiency in copper refining. Addicks	23
Cushman, Alerton S.	711
Cyanide. In gold and silver metallurgy	5
Cyanides. Fuerstlering and Philipp. (P.)	315
Cyanides. Nitrogen fixation. Bucher	315

D

Davis, Meyer	56
Decantation. Countercurrent. Eames	94
Degeckirk tungsten mill	565
De Laval centrifugal pump	660
Dessus sugar refinery	40
Detarring gas. Steere	695
Distillers' experiments	488
Dulberg, S. H.	113
Dorr, I. V. N.	132
Dorr metallurgical apparatus	113
Dreyfus, H. H.	288
Dreyfus, G.	166
Duckworth, G.	665
Drucker, A. E.	665
Dryer. Atmospheric drum	223
Drying. Air correction. Hering	360
Drying by air. Hering	187
Dumas, W.	665
Dunkle, W. E.	356
du Pont de Nemours & Co. Annual report	356

Duroloid pebbles	356
Dust collector. Robertson	662
Dutton, F. B.	288
Dwight-Lloyd sintering machine. Improvements. Gayley. (P.)	238

DYESTUFFS:

—Annual meeting of Bradford Dyers' Association	464
—Appropriation	186
—Big companies	471
—Consolidation of large companies	471
—Cooling condensing water	710
—Difficulties of British industry. Whitaker (S.)	282
—Discussion at Textile Club	384
—Japanese by-product coke and dyestuff industry	700
—Organic processes. Ney and Marle	217
—Production in U. S. in 1916	672
—Progress in the American industry. Heber	474
—Society of Dyers and Colorists Meeting. (S.)	607

E

Economics. Our economic future	675
Efficiency. Mental	466
Efficiency engineers. Poem	180
Eilers, Anton	467
Elbridge, D. F.	288
Electric drive in sugar mills	433
Electric porcelain. Barringer	433
Electrochemical industries and the Pacific Coast. Beckman	360
Electrochemical industries. Niagara Falls in 1916	7

ELECTROCHEMISTRY:

—Electrochemical analogies of photochemistry. Mott. (S.)	226
—Exhibit of Canadian Pacific Railway	455
—France. Mailoux	324
—University of Cincinnati. Daum and Davison	367
—In France. Mailoux	265
Electrocyano process	456
Electrodes. Magnetite. Thompson	605
Electrodes. Method of connecting in electrolytic refining. Whitehead. (P.)	227
Electrolytic equivalents of gases. Hering	383
Electrometallurgy in 1916	9
Electron. Enlarged. Hering	598
Electroplating. Causes brittleness in steel springs. Thompson	83
Electroplating. Papers on. (Abstracts) Electrotyping wall coverings. McIndoe. (P.)	587
Elements. Evolution of. Harkins	285
Elevators. Portable	73
Elliot Cresson Medal for E. F. Northrup	534
Elsol dry concentrator	709
Elwood, W. F.	535
Employers' responsibility. Beckman	550
Endosmosis	337
English. Engineers lack of	243
Epicassit for rust proofing	403
Equivalents of gases. Electrolytic. Hering	383
Evolution. Mostrius	358
Exfoliation in case-hardening of steel. Stenger	425
Explosives. Application of nitro-aromatics. Mardick	303
—By-products from manufacture	672
—Comment on nitro-aromatic article. Munroe	360
—Use of nitro-starch. Sadtler	361
Exports. Our export trade	242
Exports. To Hongkong	544
Exposition. Springfield	451
Exposition of Chemical Industries. Third National	670
Extraction apparatus. Automatic. Ogden. (P.)	402
Eyde, Sam	56

F

Fairlie, A. M.	166
Faraday Society. Eighty-first meeting	247
Faraday Society. Symposium on training the chemical engineer	420
Faraday Society. Symposium on osmotic pressure	680
Faraday Society. Symposium on enlarged electron. Hering	350
Farrish, F. G.	350
Federal Dyestuff & Chemical Co. Photo	364
Federal Dyestuff & Chemical Co.	474
Feldspar. Grading of. Wiard	449
Feldspar. Potash from. Blum (P.)	453
Feldspar. Potash from, in Canada. Benham. (S.)	704
Fellowships. University of Utah	536
Fellowships in metallurgy at University of Washington	708
Ferro-alloys. French production	334
—Manufacture of decafluorobenzene	307
—Manufacture of. Ladoff. (P.)	702
—New company in Denver	15

[illegible]

- Iron and Steel—Continued
 —Electric furnace production of pig iron in Sweden..... 509
 —Electric steel melting..... 577
 —Electric steel progress in England..... 533
 —Electric steel. Symposium..... 573
 —Export trade..... 242
 —Ferrous and high speed steel. Law off. (P.)..... 707
 —Ferro-manganese: Anderson, (S.)..... 705
 —Foundry cores. Electric baking..... 585
 —Foundry sand..... 663
 —Foundry, new..... 663
 —Future of the industry..... 545
 —Future of the iron blast furnace..... 17
 —Johnson, C. A. Rate plant for West Virginia..... 534
 —Grain growth in metals. Jeffries, (S.)..... 106
 —Grain growth in low carbon steel. Sherry, (S.)..... 224
 —Heat treatment. Effect of time of heating before quenching. Portevin..... 51
 —Heat treatment of high-speed tool steel. Pellis, (S.)..... 341
 —History of electric steel..... 573
 —Hot-blast stove construction. Bradley, (S.)..... 283
 —Magnetic concentration of low grade ore at Witherbee, Sherman & Co.'s plant..... 249
 —Metallography and heat treatment..... 252
 —New ferroalloy company in Denver..... 195
 —New steel mill in Chile..... 214
 —Open hearth steel construction. Our economic future..... 675
 —Phosphorus in high speed steels. Determination. Kraus..... 124
 —Picking electrolytically. Thompson..... 586
 —Pig iron statistics..... 298
 —Power plants. Rice, (S.)..... 528
 —Presidential address of E. H. Gary..... 636
 —Protecting with zinc. Hess..... 13
 —Rennerfelt electric furnace. Von Baur..... 580
 —Resistance of iron. Campbell, (S.)..... 225
 —Reversing device for regenerators. Knox, (P.)..... 163
 —Review of 1916..... 6
 —Seasoning of Castings. Moldenke, (S.)..... 342
 —Sintering iron ore. Bittmann, (P.)..... 706
 —Steel corporation's report..... 357
 —Steel from scrap. Schwartz, (P.)..... 401
 —Steel industry in Germany, (S.)..... 454
 —Steel in war..... 414
 —Steel production in 1916..... 626
 —Tonnage of iron in future..... 176
 —Tool-steel alloys. Furness, (P.)..... 164
 —Uranium steel. Flannery, (P.)..... 284
 —Vanadium determination. Kraus..... 418
 —Welding compound. Phelps, (P.)..... 163
 —Welding high-speed steel. Hope, (P.)..... 285
 —Iron-silicon acid resisting alloys. Kuwalke..... 581
- J**
 Jackson, D. D..... 166
 Jacobs, Arthur I..... 406
 Japan: Recent developments in by-product recovery..... 700
 —Japanese Chemical Industry. Nishida..... 505
 —Japanese Chemical Journal..... 480
 —Japanning oven. Electric..... 583
 —Jig. Indicating instrument..... 535
 —Johnson, J. E..... 56
 —Joplin-Miami zinc district..... 554
- K**
 Kansas City section. Resources. Boynton..... 482
 Keedy, D. V..... 113
 Kelp. Carbonization for potash. Turrentine..... 196
 Kennedy, F. A..... 286
 —Kennedy-Van Saun Corporation. Crusher..... 286
 —Kidde, W..... 232
 —Kieselguhr. Progress in the use of in metallurgical equipment..... 54
 —Kilns. Rotary for calcining lime. Wood, Kingsport Extract Corporation. Photo..... 365
 —Kingsport Pulp Corporation..... 365
 —Kithell, K. I..... 113, 166
 —Koven, L. O..... 113
- L**
 Laboratory organization. Coarse..... 690
 —Laboratory. University of Cincinnati..... 471
 —Laib, Walter..... 350
 —Laist, Fred..... 56
 —Laurie, G. W..... 665
 —Laziness. Efficiency and efficient laziness. (Ed.)..... 69
- Lead burning apparatus..... 709
 Leads for electric furnaces. Lindstrom..... 683
- LEAD:**
 —Calculation of blast furnace charges. Dudley..... 87
 —Calculation of lead blast furnace charges. Dudley..... 129
 —Matter granulation at Bercelaneum, Mo. Lindau, (S.)..... 106
 —Mills in Southeast Missouri..... 472
 —Leather. Recent advances. Rogers..... 524
 —Leblanc steam jet refrigerating machine (S.)..... 224
 —Leeds & Northrup. Critical point apparatus..... 165
 —Lemmer, C. A..... 56
 —Levin, A. R..... 113, 232
 —Library. Great library of applied science. Walker..... 676
 —Library. United Engineering..... 546
 —Lidbury, F. A..... 165
 —Liebig scholarships..... 399
 —Light. Vosmaer phenomenon. Mooie..... 557
 —Lime kilns. Brick used..... 215
 —Lime calcining in rotary kilns. Wood..... 430
 —Lime process of desulfurization..... 113
 —Linden, H. E..... 166
 —Liquids. Automatic testing..... 287
 —Liquids. Wet gage..... 610
 —Liquids. Electrical treatment. Landreth (P.)..... 227
 —Liquids. Transportation of corrosive liquids by water..... 350
 —Little, A. D..... 350
 —Floyd, Morton G..... 582
 —Low-temperature electrothermal processes. Lirshfeld..... 692
 —Lubrication. Testing of oils. Moore..... 288
 —Richter..... 113
 —Luty, B. E. V..... 665
 —Lyon, Dorsey A..... 711
- M**
 McCoy, H. N..... 350
 —McCreary, J. H..... 711
 —MacDonald, Bernard..... 297
 —McGraw-Hill Consolidation..... 307
 —McGraw-Hill Publishing Co., Inc. Evolution of..... 307
 —McGraw, James H. (Photo.)..... 166
 —McHugh, P. M..... 288
 —McKay, D. I..... 166
 —McKenna, W. H..... 209
 —Magnesia brick..... 190
 —Magnesite. Deposits worked in Washington..... 319
 —Magnesium Products Co..... 605
 —Magnesian Salts. Patton..... 654
 —Magnetite electrodes. Thompson..... 288
 —Malt. Grading of. Wiard..... 344
 —Marchant, R. B..... 417
 —Marcy mill data. Marcy..... 56
 —Marsh, G. A..... 457
 —Marshall, A. E..... 166
 —Marshall, S. M..... 232
 —Martin, O. C..... 492
 —Mason, John G..... 310
 —Massachusetts Institute of Technology, co-operative research..... 457
 —Massachusetts Institute of Technology. Work begun in chemical engineering practice school..... 56
 —Mathews, J. A..... 106
 —Mathewson, E. P..... 404
 —Matte granulation. Lindau, (S.)..... 529
 —Mellon Institute. Growth of..... 530
 —Melting brass. Thornton, (S.)..... 606
 —Melting metals at mint in England, (S.)..... 529
 —Melting metals. Hering, (S.)..... 529
 —Melting metals. High pressure gas. Walter, (S.)..... 529
 —Melting metals in electric furnace. Greenwood, (S.)..... 529
 —Melting metals with coal gas. Brooks, (S.)..... 530
 —Mercury. Roasting furnace and fume condenser. Whitman, (P.)..... 706
 —Merrill, I. L..... 113
 —Metals. Melting of Hering, (S.)..... 606
 —Metals. Volatilization of. Clawson, (P.)..... 285
 —Metric System. American Metric Association..... 216
 —Metzger, F. J..... 167
 —Metzger, F. J. Dinner to..... 558
 —Mexico—What will the final outcome be? Y. N..... 10
 —Miami Copper Co. Appellate Court rotation suit decision..... 629
 —Miami Copper Co. Flotation Suit..... 181
 —Miami flotation suit. Court of Appeals decision..... 677
 —Michigan Limestone & Chemical Co. Large crusher..... 286
 —Mill. Marcy mill data..... 344
 —Mills. Ball. Hardinge..... 417
 —Mills. New western..... 245
 —Mills, C. E..... 113
 —Minerals Separation Suit against James M. Hyde. Decision..... 21
 —Minerals Separation North American Corporation..... 84
 —Miami suit..... 181
 —Suit..... 469
- Mining and Metallurgical Society..... 128
 Mississippi Centennial Exposition..... 384
 Missouri. Lead mills. (Photos.)..... 473
 Molasses. Beet. Osborn..... 306
 Molybdenite. Flotation..... 306
 Molybdenum: Preparation and uses of pure metal. Humphries..... 678
 Molybdic acid. Recovery from phosphorus filtrates. Hagmar..... 12
 Monarch Manufacturing Works. Nozzles..... 404
 Montana State College..... 549
 Morley, Edward W. Willard Gibbs Medalist..... 653
 Motherwell, Wm..... 56
- N**
 National Aniline and Chemical Co., Inc..... 418
 National Lime Manufacturers' New York meeting. Note..... 186
 National Potash Corporation: Potash from feldspar..... 704
 —National Research Council..... 472
 —National Safety Council's monthly leaflets..... 180
 —National Zinc Company's plant..... 490
 —Nar By Mining Co..... 245
 —Nevada Consolidated Copper Co. Annual report..... 632
 —New York Revolving Portable Elevator Co. Ney, A. H..... 535
 —232
- NIAGARA FALLS:
 —Efficiency and legislation..... 241
 —Power situation..... 175, 244, 300
 —Power famine..... 175, 244, 300
 —Resolutions of American Electrochemical Society..... 569
 —Review of operations in 1916..... 570
 —Suicide of Harper..... 1
 —Nice and Poor..... 1
 —Nichrome-constantan thermo couple. Woodward and Harrison..... 647
 —Nickel. New developments in Canadian industry..... 27
 —Extraction in electric furnace. Rebert, (P.)..... 343
 —Manufacture of neutral salt. Addicks..... 691
 —Plating. Parker, (P.)..... 284
 —Waste heat boilers with nickel-refining furnaces. Pratt..... 31
 —Welding compound. Samscreuther, (P.)..... 707
- Nickel carbide..... 530
 Nickel chromium alloys. Analysis..... 218
 Nickel-chrome alloy. Irix, (P.)..... 329
 Nitrates. Chilean industry..... 525
 —Industry in Chile. Holshaw..... 253
 Nitric Acid. (See also Nitrogen: Fixation)
 —In France..... 325
 —New Swedish company..... 227
 Nitro-aromatics. Application in explosive industry. Markie..... 303
 Nitro-aromatics as explosives bases. Comment on article. Munroe..... 360
- NITROGEN, FIXATION:
 —As cyanide. Bucher..... 315
 —Electric furnace for treating gases. Mosicki, (P.)..... 53
 —In France..... 325
 —Improvements in Birkeland-Eyde furnace. Dove, (P.)..... 53
 —Improvements in Birkeland-Eyde furnace. Dove, (P.)..... 108
 —New furnace design. Scott, (P.)..... 53
 —Schönberg furnace improvements. Edwin, (P.)..... 361
 Nitro-starch. As an explosive. Sadler..... 108
 Noble, Paul..... 232
 Northrup, E. F..... 232
 —Northrup, E. F. Receives Elliott Cresson Medal..... 180
 Norway: Nansen fund for chemical and physical research..... 319
 —Norwegian engineers' congress..... 630
 —Noyes, W. A..... 56
 —Nozzles: Stoneware atomizing..... 404
- O**
 Of, Charles..... 406
 Ohio Northern University. Exhibit. (Note)..... 335
- OILS: (See also Petroleum.)
 —Analysis of light oils. Egloff..... 259
 —California fields..... 454
 —Cracking apparatus. Higley, (P.)..... 659
 —Cracking petroleum in liquid phase. Cross..... 643
 —Essential, as addition agents in plating..... 587
 —From shale in Colorado..... 180
 —Fuel oil requirements new..... 50
 —Separation of. Cornell, (P.)..... 53
 —Testing of lubricating oils. Moore and Rice..... 692
 Oil stills. Use of waste heat boilers with. Pratt..... 31
 Oil Shale Mining Co..... 180
 Old Dominion Copper Mining & Smelting Co..... 247
 O'Loughlin, L. J..... 485
 Ore reduction: Electric furnace. Moffat, (P.)..... 285

Organization. Riot of.....	67
Osmotic pressure.....	615
Osmotic pressure. Symposium before Faraday Society.....	680
Oxidation. Hering.....	598
Oxidation in physical chemistry. Hering.....	507
OXYGEN:	
—Air Reduction Co. expands.....	164
—Explosions due to hydrogen.....	402
—French manufacture.....	327
—Generator. Mueller and Rowlands. (P.).....	531
—Generator. Levin (P.).....	451
—Generator. Sanders (P.).....	453
—Generator. Schille (P.).....	610
—German oxygen and hydrogen manu- facturers in Germany form com- bine.....	25
—Possibilities of oxygen blast for iron blast furnaces. Johnson.....	19
—Generator. Mueller and Rowlands. (P.).....	453
Ozokerite. New plant. Uses.....	246

P

Paint. Radio-luminous.....	418
Palau crucibles.....	533
Palladium-gold as platinum substitute.....	533
Paper. Manufacture from Kaing grass.....	52
Paraffin hydrocarbons. Stability of. Eg- loff and Moore.....	47
Patriotism in chemistry.....	297
Periodic table of elements. Harkins.....	73
Perkin medal. Program for presentation meeting.....	76
Perkin Medal. Presented to Ernst Twitchell. Report of meeting.....	141
Peru. Exports to United States.....	717
Peters. Edward Dyer.....	289
PETROLEUM. (See also Oils.)	
—Benzene, toluene and xylene from. Egloff.....	492
—Benzene and toluene from cracking. Bender. (S.).....	657
—Cracked gasoline production. Ritt- man.....	555
—Cracking in liquid phase. Cross.....	643
—Decomposition of paraffin hydrocar- bons. Egloff and Moore.....	76
—Gasoline from oil shales.....	71
—Nature and origin. Richardson.....	23
—Public session of American Chemical Society.....	483
—Situation. Manning.....	631
—Stability of paraffin hydrocarbons. Egloff and Moore.....	47
Pettis, E. S.....	711
Peterson, G. R.....	289
Philippines. Possibilities for rubber plan- tations. King.....	103
Phosphoric acid. Electric furnace pro- cess. Hechenbleikner (P.).....	107
Phosphoroscope. Andrews (S.).....	399
Photochemical cell.....	587
Photochemistry. Electrochemical analo- gies. Mott (S.).....	226
Physical chemistry. Derick.....	76
Picric acid. For explosives.....	304
Pigment. Titanic oxide.....	603
Pingue plant. As a rubber producer.....	100
Pitch. Use in England. (S.).....	107
Plant Life. Damage by smelter smoke. Pitting. Nickel. Parker (P.).....	284

PLATINUM:	
—In Colorado.....	246
—Production in 1916.....	624
—Requisitioned by Russia.....	411
—Resolutions on use.....	566
—Russian industry.....	543
—Substitute.....	533
—Supply of.....	508
Porcelain. American. Quaintance.....	548
—Bleining.....	589
—Chemical and electrical meeting. Short report.....	182
—Chemical. Binns.....	395
—Electrical. Barringer.....	433
Portland Gold Mining Co.....	306
Postage rates. Increase of second class.....	626

POTASH:	
—Case of the Government against the Tron.....	19
—From blast furnace. Wysox.....	205
—From California.....	412
—From cement mills.....	653
—From cement. Riverside plant.....	701
—From feldspar. Blumenberg (P.).....	453
—From feldspar in Canada. Benham. (S.).....	704
—From Kelp. Turrentine.....	197
—From molasses.....	443
—Possibilities in Oregon. Van Oschel	549
—Statistics for 1916.....	356
Potassium chlorate. In Japan.....	273
Potsdam, L. S. Blumenberg.....	406
Pottery. Zinc works.....	475
Press. Asbestos.....	543
Precipitation of fume by electricity. The- dry.....	638
Pressure regulator for pulpwood grinders Price, R. B.....	534
Prices. Government fixing.....	625

Primos Chemical Co. Tungsten mill.....	565
Producer gas. Steere.....	695
Prospectors. Course for at University of Utah.....	128
Providence Engineering Society. Meet- ing.....	474
Public relations. Presidential address. Fitz Gerald.....	571
Puget Sound Traction, Light and Power Co.....	614
Pulpwood. Grinder.....	534
Pump. Combined steam turbine and cen- trifugal.....	660
Pumps. Diaphragm used in decantation.....	97
Pyrometers. Brown. (S.).....	705

Q

Quartz glass. Manufacture. Trautmann. (P.).....	343
Quicksilver; see Mercury.....	

R

Raddant, W. C. Liquid testing device.....	166
Radium. Amount tested by Gov't.....	105
Radium plant in Colorado.....	418
Railroad congestion. (Ed.).....	121
Ralston, O. C.....	167
Ramsburg, C. J.....	167
Rat problem.....	360
Rat problem. (Ed.).....	122
Reactions. Secondary. Hering.....	300
Reduction in physical chemistry. Her- ing.....	507
Reduction. Hering.....	598
Refractories. Bureau of Standards to study.....	22
Refractories. Carbon tube furnace for testing. Griffiths (S.).....	225
Refrigeration. Steam jet machine. Bertsch (S.).....	224
Refuse. Use of for power generation. Kershaw.....	426
Replogle, J. L.....	209
Research and industry. Choate.....	244
Research laboratories. More publicity urged.....	179
Research. Promotion of at universities.....	472
Research. Relation to everyday life. Weems.....	225
Resistance. Specific. Of iron. Canphill. (S.).....	478
Respirators.....	672
Richards, A. C.....	56
Richards, C. R.....	56
Richards, J. W. Personal note.....	70
Rickard, J. H.....	232
Ritman cracking process. Bender. (S.).....	657
Riverside Portland Cement Co. Potash plant.....	701
Robertson dust collector.....	662
Rose, Robert E.....	617
Rosenthal, Charles H.....	587
Rosin. Uses of.....	623
RUBBER:	
—Glossary of terms. Danerth.....	380
—Situation. King.....	399
—Solvent recovery. Weher. (S.).....	399
—Specific gravity in compounding.....	655
—Synthetic. King.....	111
—Vulcanization. Ostromeyski. (S.).....	161
Rubber Club. Annual meeting.....	128
Rust-proofing compound.....	403
Rutile. Analysis. Hagmaler.....	588
Ryan, F. C.....	350

S

Safety in the larger sense. Rindge.....	551
Salt. By solar evaporation. Palmer.....	317
Salt. Production in Szechuen province, China. Western China. Richardson.....	32
Saltpetre. In Chile.....	253
Saunders, L. E.....	457
Sauveur, A.....	617
Schmerka, F.....	536
Schlesinger Radium Company.....	418
Scholarships. German.....	399
Scholl, Guilford D.....	665
Schroth, R. C. Jr.....	232
Schubert, Robert.....	201
Schultz, R. W.....	56
Screens. Standard scale.....	340
Seagrave, W. H.....	665
Selby Smoke Commission.....	193
Shale. Oil from in Colorado.....	180
Shales. Gasoline from.....	71
Shanghai. Exports to U. S.....	543
Shingles. Centrifuge.....	190
Shaw, Dudley.....	167
Sieves. Standard scale.....	340
Slits brick. New uses. Gray.....	209
Sill and Still.....	54
Silicel. Progress in use of.....	54
Silver. Plating.....	587
Simmons, John C. Automatic liquid weigher.....	110
Singmaster, J. A.....	537
Sinn, Francis P.....	113

Sintering. Improvements in Dwight-Lloyd apparatus. Gayley. (P.).....	228
Sintering fine ores. Bittmann. (P.).....	706
Sintering metals. Walling. (P.).....	228
Smelting. Smelt problem. Johnson.....	199
Smoke. See also fume.....	
Smoke abatement. Monnett. (S.).....	400
Smoke. Condensation of fume. Breiten- stein.....	284
Smoke. Condenser. Simoney (P.).....	284
Smoke problems.....	483
Smoke. Symposium on smoke and fume problem.....	128
Smoke problem. Legal phases. Johnson Snyder, A. M.....	199
Soap. Description of Twitchell process. Ittner.....	537
	144

Society of Chemical Industry:	
—N. Y. Section. Colloid chemistry and leather.....	474
—New York Section. Meeting.....	630
—New York Section. Program of Per- kin Medal meeting.....	76
Society of Dyers and Colourists. Annual meeting.....	607
Society of Glass Technology (England). Note on formation.....	167
Soda. Caustic and alkali metals. Ash- croft.....	327
Soda manufacture in France.....	107
Sodium cyanide.....	418
Sodium cyanide. Manufacture of. Bu- cher.....	82
Sodium cyanide manufacture. Bucher.....	316
Sodium hydroxide. Action in steel.....	496
Sodium. Merica.....	416
Sodium. Metallic. McNitt. (P.).....	401
Sodium nitrate. Industry in Chile. Hobshaw.....	253
Soldering compound for aluminum. Stew- art (P.).....	630
Solvent recovery in rubber industry. Weber. (S.).....	399
Southern Potteries, Inc. Photo.....	364
Southwestern Engineering Co. K and K floatation machine.....	346
Southwestern Society of Engineers orga- nized.....	405
Spilsbury, E. G.....	711
Springfield Industrial exposition.....	451
Springs. Brittleness caused by electro- plating. Thomson and Richard- son.....	83
Stabel, Joseph.....	56
Staso Milling Co. Cottrell precipitator.....	336
Statistics. Production for 1916.....	738
Steffen process of sugar making.....	440
Stills. Use of waste heat boilers with oil stills. Pratt.....	31
Stockwell, R. K.....	167
Storage batteries. Use of tungsten. Koerner.....	657
Stoves: Hot-blast. Construction. Bradley. (S.).....	283
Strontium. Production in 1916.....	356
Strontium. Production in U. S. James. (S.).....	342
Suckow, V. C.....	711
Sugar: Beet molasses. Osborn.....	437
—Electric drive in sugar mills.....	288
—From beets. Benjamin. (P.).....	286
—Large beet crop in 1917.....	107
—Sugar content of sugar beet. Wiech- man.....	76
—Testing liquid automatically.....	166
Sulphur: Effect on lowboiler.....	341
—Hayward. (S.).....	341
—Production from sulphur fumes. Young.....	309
—Recovery from smelter smoke. Breit- enstein. (P.).....	284
Sulphuric acid. Stoneware atomizing nozzles.....	404
Sulphuric acid. Use of electric discharge. Kee and Wedge (P.).....	532
Sulphidizing. Use in 1916.....	3
Sulphuric Acid. For use in making in- termediates.....	218
Sulfurous Acid. Electrolytic oxidation. M. R. Thompson and M. de Kay Thompson.....	179
Surface combustion in galvanizing. Harris. Steele, S. B.....	613
Stone. Grading of. Ward.....	288
Stroh Steel Hardening Co.....	296
Strontia process in sugar making.....	440
Sweasy. Ambrose.....	711
Switzerland and the chemical industry.....	415
Switchboard for experimental furnace work. Badger. (S.).....	704
Switzerland. Chemical industry.....	78

T

Tackaberry, F. H.....	711
Tank. Improved wood.....	610
Tanning. By electricity. Grob. (P.).....	609
Tantriton. Not dutiable.....	239
Tariff and business commissions.....	77
Technical Association of Paper and Pulp Industry. New York convention. Note.....	186
Teeple, John E.....	167
Teknik Club meets at Denver.....	84

Temperature control. Automatic.	347	University of Kansas.	490
Tennessee. New industrial plants.	365	Uranium. Ferro.	488
Textile Club. Discusses dyes.	384	Uranium steel. Plannery. (P.)	284
Thermocouple nichrome-constantan. Woodward and Harrison.	647	Utah Power & Light Co., Supreme Court decision.	366
Thermometers. Automatic.	348	Utah. University of. Fellowships.	536
Thickener. Dorr.	96	Utilization of waste heat for steam-generating purposes. Part 2. Pratt	27
Thickener. Tray. Dorr.	98		
Thies, C. E.	537		
Thiogen process for removing sulphur fumes. Young.	339		
Third exposition of chemical industries.	679		
Thomas, K.	406		
Thompson, M. R.	457		
TIN:			
—Polivian exports.	623		
—Conserving tin plate supply.	717		
—Corrosion of tinned sheet copper.			
—Merica. (S.)	657		
—Electrolytic recovery. Battle. (P.)	107		
—Government conserving tin.	624		
—National Lead's smelter.	443		
—New producer in South Dakota.	296		
—New smelter for Chile.	566		
Titanium Alloy Co.	296		
Titanium. Analysis of rutile. Hagmaier	588		
—Titanic oxide from ilmenite ores.			
—Barton. (P.)	164		
—Titanic oxide pigment.	603		
Todd, C. H.	617		
Toluene. From petroleum. Egloff.	492		
Topnaph Belmont Development Co.	419		
Topnaph Mining Co.	72		
Topping, A. R.	663		
Tracy, Stanley M.	113		
Trade agreements.	25		
Transportation of corrosive liquids by water. Morris. (S.)	227		
Trinitrotoluol. For explosives.	304		
Trinitrotoluol tax held illegal.	671		
Trumbull, H. L.	617		
Tube mill lining.	671		
TUNGSTEN:			
—Electrolytic behavior. Koerner.	40		
—Electrolytic production. Keyes. (P.)	107		
—Flotation of ores.	306		
—Manufacture in England. (S.)	225		
—Modern concentration. Fischer.	559		
—Production of malleable tungsten.			
—Helfgott. (P.)	284		
—Sintering. Walling. (P.)	228		
Tungstic acid. Colorado.	419		
Tungsten-molybdenum alloys.	249		
Tungsten Products Company.	419		
Turpentine. Uses of.	544		
Twitchell, Ernst. Receives Perkin medal	141		

U

Uppington, G. P.	537, 617
United Engineering Library. Walker.	676
United Engineering Societies Library.	546
Universal Tank Gage Co.	287

Valency and valence. Wilson.	13
Valence. Crossley.	76
Valves. Anti-acid.	464
Vanadium. Analysis in steel. Kraus.	418
Vapor pressure of metals.	484
Vaporization of copper. Butts.	85
Varley, Thomas. Tungsten mill.	564
Vindicator Consolidated Gold Mining Company. Financial report.	16
Viscometers. Calibration of. Bingham. (S.)	453
Vosmaer phenomenon. Moore.	357
Vought, C. S.	617
Wages in the hereafter.	299
War. Editorial on.	413
War. Presidential address of E. H. Gary.	634

W

Waldo hardness tester.	710
WATERPOWER:	
—A story illustrating conditions at Niagara.	124
—Compared with by-product gas producer. Tarr.	373
—Decision of U. S. Supreme Court.	366
—Efficiency and legislation.	241
—In France. Mailloux.	265
—Niagara famine. Johnson.	244
—Niagara Falls famine.	175
—Niagara Falls famine. Lidbury.	300
—Niagara situation.	77
—Our wasting. L. B.	70
—Pacific Coast. Beckman.	360
—Resolutions of American Electrochemical Society.	569
—Versus gas.	357
Waterproofing cloth. Tate. (P.)	286
Watts, E. E.	457
Wax. From black liquor.	416
Webb, A. M.	233
Weedon Mining Co., Electrolytic zinc tests.	646
Weigl, W. M.	233
Weighing. Automatic liquid weighing.	110
Weiss, H. F.	406
Welding. Compound for welding iron and steel. Phelps. (P.)	163
—Compound for nickel. Samseurether. (P.)	707

Welding—Continued	
—Constant-current system.	108
—High-speed steel. Hope. (P.)	284
Wellman, S. T.	711
Wells, A. E.	457
Werner, V. H.	289
Western Salt Co., solar evaporation plant.	
Westinghouse Electric & Mfg. Co.	317
Whitaker, M. C.	617
Whitaker, M. C. Dinner to.	558
Whiting, Bruce L.	537
Who?	180
Wielgolashi, F. H. A.	113
Wilkinson, T. K.	113
Willard Gibbs Medal.	653
Will, R. T.	537
Williams, Harvey & Co.	443
Williams Patent Crusher and Pulverizer Co.	296
Wine. Aging of. Lachmann. (P.)	54
Wittenau, E.	665
Wolf Tongue Mining Company's mill.	559
Wood oils. Hydrogenation.	708
Wood tank. Improved.	610
Woodwell, C. S.	289
Worth, B. G.	289

Y

Young Men's Christian Association.	323
Young Men's Christian Association.	551
Young Men's Christian Association. Industrial work. (Ed.)	123
Youngstown Chemists' Club.	158
Youngstown Chemists' Club Meeting.	707

Z

ZINC:	
—Determination of. Hastings.	263
—Electrometric determination.	484
—Hydrometallurgy.	485
—Hydrometallurgical and electrolytic treatment. Watts.	645
—In France.	334
—Metallurgy of. Johnson.	375
—New electric smelting furnace. Fulton. (P.)	158
—New Kansas-Oklahoma fields.	484
—Resources of Joplin-Miami district. (Illustrated)	554
—Separation from cadmium.	484
—Symposium of American Chemical Society.	484
—Tendencies in the industry. (Ed.)	673
—Use of zinc dust in gold and silver metallurgy in 1916.	5
—Use of, in coating iron and steel for protection. Hess.	13
—Waste heat boilers with zinc furnaces. Pratt.	30
—Works pottery. Johnson.	475
—Oxide. Cottrell precipitator.	337
Zirconium oxide.	412
Zirconium alloys. Cooper. (P.)	660

AUTHOR'S INDEX

- A. B. C. A fable it will seem in years to come. 628
 —Legal status of flotation processes. 126
 Addicks, Lawrence. Current density in copper refining. 311
 —Current efficiency in copper refining. 23
 —Impurities in electrolytic copper refining. 687
 Anderson, Robert J. United States in the realm of research. 360
 —Ferromanganese. (S.). 705
 Andrews, W. S. An improved phosphoroscope. 399
 Atchison, T. C. and M. McKay Thompson. Production and properties of magnetite electrodes. 605
 Ayres, Eugene E. Effect of centrifugal force on colloidal solutions. 190
- BADGER, W. L. Switchboard for experimental furnace work. (S.). 704
 Barnett, Maurice, and Louis Burgess. Manufacture of aluminum carbide. (S.). 609
 Barnitt, J. B. Plastic cements. 321
 Barrister, Harry L. Production of hydrogen by the iron content method. 611
 Barringer, L. E. Electrical porcelain. 433
 Beckman, J. W. Electrochemical industries and hydroelectric power on the Pacific coast. 360
 —Employment of high-speed tool steel. 530
 Bellis, A. E., and T. W. Hardy. Heat treatment of high-speed tool steel. (S.). 341
 Bender, Andrew. Effect of cracking petroleum oils. (S.). 657
 Benham, D. J. Potash from feldspar. (S.). 704
 Heininger, A. R. Corrosion. 589
 Bertsch, J. C. Steam jet refrigerating machine. (S.). 224
 Bingham, Eugene C., and Richard F. Jackson. Calibration of viscometers. (S.). 453
 Binns, Chas. F. Chemical porcelain, its production and quality. 395
 Bousfield, W. R. Osmotic pressure. 680
 Bradley, Linn. Coating process in practice. 336
 —and H. D. Egbert and W. W. Strong. Construction of hot-blast stoves. (S.). 282
 Briner and Senglet. Researches on the carbides of aluminum, copper and nickel. (S.). 530
 Brooks, George P. J. Effect of melting non-ferrous alloys. (S.). 530
 Brown, Richard P. Pyrometers. (S.). 705
 Bucher, John E. Fixation of nitrogen as cyanide. 315
 Buck, C. A. The Bethlehem 10-ton Girod steel furnace. 578
 Burgess, Louis, and Maurice Barnett. Manufacture of aluminum carbide. (S.). 609
 Butts, Allison. Vaporization of metallic copper in wirebar furnaces. 85
- CALLOW, J. M. Notes on flotation. (S.). 250
 Campbell, E. D. Specific resistance of iron. (S.). 225
 Carney, Frank D., and Lewis B. Lindemuth. Duplex steel process. (S.). 609
 Chandler, C. F. Peirce medal address. 141
 Choate, Parker C. Evasion of patent suit decisions. 469
 —Research and industry. 244
 Cross, Roy. Crystallization of petroleum in the liquid phase. 633
- DANNER, FREDERICK. Glossary of terms used in the rubber industry. 380
 Davison, Albert Watson, and Ernest Edgar. Metallurgy and electrochemistry at the University of Cincinnati. 367
 DeCew, J. A. Some studies on the methods of recovering antimony from its ores by volatilization processes. 444
 Denis, Theo. C. Aluminum production of Canada. 628
 Dixon, J. L. Electrolytic melting. 577
 Dudley, Boyd, Jr. Calculation of lead blast furnace charges. 87, 129
- JAMES, LUTHER B. Countercurrent decantation. 94
 Edwards, Junius David. Effusion method of determining gas density. 518
 Egbert, H. D., Linn Bradley and W. W. Strong. Construction of hot-blast stoves. (S.). 282
 Egloff, Constat. Analysis of oils. 251
 —and R. J. Moore. Stability of paraffin hydrocarbons. 47
- Benzene, toluene and xylene from petroleum. 492
 Estes, Clarence. Bibliography of alloys. Binary, ternary and quaternary systems whose equilibria have been investigated. 273
- FAHRENWALD, A. W. A convenient and inexpensive electric furnace for high temperatures. 565
 Fahrenwald, F. A. Tungsten-molybdenum alloys. (S.). 249
 Fairlie, Andrew M. Control of chamber process of making sulphuric acid. 149
 Finlay, J. R. Individual effort versus corporate effort. 301
 Fischer, Martin H. Colloid and emulsion chemistry. 474
 Fischer, S. Jr. Modern concentration of Colorado tungsten ores. 559
 FitzGerald, Francis A. J. Committee on public relations. 571
 Flinterman, R. F. Electric furnace in the steel casting plant. 574
- GARY, ELBERT H. Presidential address to the American Iron and Steel Institute. 634
 Gillett, H. W., and G. M. James. Melting aluminum chips. (S.). 52
 Gray, Walter. New uses for silica brick. 209
 Greenwood, H. C., and R. S. Hutton. Melting metals in the electric furnace. 529
 Griffiths, E. and E. A. Carbon tubes for testing refractories. (S.). 225
 Groth, Lorentz A. Electroplating. (S.). 609
- HAFF, M. M. Power for aluminum production. 468
 Hagmaier, E. W. Recovery of chlorine from solutions. 70
 —Recovery of molybdic acid from phosphorus filtrates. 12
 —Glass analysis. 604
 Harding, H. W. Ball mills. 417
 Hardy, T. W., and A. E. Bellis. Heat treatment of high-speed tool steel. (S.). 341
 Harkins, Wm. D. Structure of matter. 73
 Harper, John. L. Sulfide of the Niagara Horseshoe Falls. 570
 Harris, William J., Jr. Surface combustion applied to galvanizing. 613
 Harrison, T. K., and R. V. Woodward. Note on the thermocouple nichrome-constantan. 647
 Hart, Edward. A chemist's vacation. 13
 Hartley, Harold, and H. M. Thornton. Melting of brass. (S.). 529
 Hastings, J. H. Determination of zinc. 263
 Hayward, Carl R. Effect of sulphur on low-carbon steel. (S.). 341
 —and S. S. Raymond. Effect of time in reheating hardened steel. (S.). 342
 Hendrick, Ellwood. Chemical credits. 126
 Henrich, Carl. Function of alumina in slags. (S.). 249
 Hering, Carl. Melting of non-ferrous metals. (S.). 606
 —Air drying. (S.). 187, 360
 —Secondary reactions. (S.). 383
 —Electrolytic equivalents of gases. 383
 —An enlarged electron of practical size. 598
 —Printers' errors. 469
 —Oxidation and reduction in physical chemistry—consistency of terms and conceptions. 507
 Hess, Henry. Protection of iron and steel. 13
 Hirschfeld, C. F. Low-temperature electrothermal processes. 582
 Hoshawn, J. Berkwood. Nitrate industry in Chile. 253
 Hocking, W. J. Metal melting at the mint in England. (S.). 530
 Humphries, C. H. Molybdenum. 677
 Hutton, R. S., and H. C. Greenwood. Melting metals in the electric furnace. (S.). 529
- ITNER, M. H. Twitchell process in soap and candle industry. 144
- JACKSON, RICHARD F., and Eugene C. Bingham. Calibration of viscometers. (S.). 453
 James, B. W. Production of strontium in the U. S. (S.). 342
 Jeffries, Zay. Grain size determination. 503
 —Grain growth phenomena in metals. (S.). 106
- Johnson, Edward Mackay. Zinc works pottery. 475
 —Notes and experiments pertaining to the metallurgy of zinc. 375
 Johnson, J. E., Jr. Future of the iron blast furnace and legal phases of the smoke problem. 17
 Johnson, Ligon. History and legal phases of the smoke problem. 199
 Johnson, W. McA. Niagara Falls power famine. 244
- KERSHAW, JOHN B. C. Utilization of waste-products and of low-grade fuels for power generation. 229
 King, Andrew H. Synthetic rubber. 511
 —Rubber situation. 99
 —Specific gravity in rubber compounding. 655
 Koeppling, Emil D. Analysis of nickel-chromium alloys. 319
 Koet, Edward J. Rapid analysis of journal bearing linings and babbit metal. 300
 Koerner, Walter E. Electrolytic behavior of tungsten. 40
 Kowalke, O. L. Acid-resisting properties of some refractory alloys. 581
 Kraws, Edward C. Vanadium check in high-speed steel analysis. 418
 —Determination of phosphorus in high-speed steel. 724
 Kurahashi, T. Japanese by-product coke industry. 100
- AMONT, Robert P. Manufacture of steel castings. (S.). 629
 Landreth, C. P. Electrical liquid treatment. (S.). 610
 Langmuir, A. C. Twitchell process and the glycerine trade. 143
 Lathe, Frank E. Training the works chemist. 103
 Lawrence, Jas. C. Methyl alcohol and acetone. 416
 —The soda pulp industry. 70
 L. B. Our wasting water powers. 70
 Lessing, Dr. R. Recovery of benzol from coal gas. (S.). 283
 Lewis, Gilbert N. Structure of matter. 72
 Lewis, James O., and Wm. F. McMurray. Conservation of natural gas in oil fields. (S.). 161
 Lidbury, F. Austin. Niagara Falls power famine. 300
 Lindan, S. P., and H. B. Smith. Matte granulation at Herculaneum, Mo. (S.). 106
 Lindemuth, Lewis B. and Frank D. Carney. Duplex steel process. (S.). 609
 Lindström, Arvid. Leads for electric furnaces. 683
 Ling, A. R. Artificial fertilizers. (S.). 609
- MAILLOUX, C. O. Hydroelectric power and electrochemistry and electrometallurgy in France. 265, 324
 —Power for aluminum production. 468
 Manning, Van H. Petroleum and gasoline situation. 630
 Marcy, F. E. Notes on ball milling with special reference to the Marcy mill. (S.). 344
 Mardick, John R. Application of ultraromatics in explosive industry. 303
 Mathesius, Walther. Chemical reactions of iron smelting. 636
 Mathews, John A. Comments on the electric steel industry. 573
 Merica, Paul D. Corrosion of tin-plated sheet copper. (S.). 657
 —Embrittling action of sodium hydroxide on mild steel and its possible relation to seam failures of boiler plate. 496
 Miles, H. D. Chemical engineering equipment. 154
 Miller, Geo. A. Comparison system for determining and standardizing the grain size of annealed brass. 378
 Millikan, R. A. Structure of matter. 73
 Molkenke, Richard. Seasoning of castings. (S.). 342
 Moody, Herbert R. Call for the chemist. 641
 Monnett, O. Osborn. Smoke statement. (S.). 400
 Moore, H. K., and G. A. Richter. Testing of lubricating oils. 692
 Moore, R. J., and Gustav. Effect of stability of paraffin hydrocarbons. 47
 Moore, William C. Vosmaer phenomenon. 557
 Morris, H. N. Transportation of corrosive liquids by water. (S.). 227
 Moss, Sanford A., and Richard H. Rice. Power plants for blast furnaces and steel mills. (S.). 529
 Mostowitsch, W., and W. Pleneff. Volatility of gold at high temperatures. 153

- Mott, Wm. Roy. Chemistry of the flaming arc. 581
 —Electrochemical analogies of photochemistry. (S.) 526
 Munroe, T. B. Application of nitroaromatics in the explosive industry. 360
 Muntz, G., and E. Ronbien. Steel foundry sand. (S.) 399
 Mutscheller, A. Equilibrium of the basic bismuth salts. 594
- NEY, A. H., and D. J. Van Marle. Manufacture of dyestuff intermediates. 217
 Nishida, H. Japanese chemical industry. 505
 Norton, S., and S. Le Fevre. Magnetic concentration of low-grade magnetic iron ore. (S.) 249
- OSBORN, SIDNEY J. Beet molasses: its composition and utilization. 436
- PALMER, LEROY A. Salt manufacture by solar evaporation of sea water. 317
 Parker, R. G., and A. J. Dalladay. Union of glass by heat treatment. (S.) 226
 Pletneff, W., and W. Mustowitsch. Volatility of gold at high temperatures. 153
 Porter, Alfred W. Osmotic pressure. 680
 Portevin, Albert. Influence of time of heating on quenching. (S.) 51
 Pratt, Arthur D. Utilization of waste heat for steam generating purposes. 27
- QUAINTANCE, CHAS. F. American chemical porcelain. 548
- RALSTON, OLIVER C. Metallurgy of cadmium. 146
 Raymond, S. S., and Carle R. Hayward. Effect of time in reheating hardened steel. (S.) 342
 Rice, Richard H., and Sanford A. Moss. Power plants for blast furnaces and steel mills. (S.) 529
 Richards, Joseph W. Personal note. 70
 Richardson, Clifford. Nature and origin of petroleum and asphalt. 25
 Richardson, C. N., and M. de Kay Thompson. Brittleness in steel springs from electroplating. 83
 Richardson, E. A., and L. T. Corrosion of cast iron. 582
 Richardson, H. K. Production of salt in Szechuen Province, Western China. 32
 Richter, G. A., and H. K. Moore. Testing of lubricating oils. 692
- Rindge, Fred. H., Jr. Safety in the larger sense. 551
 Rittman, Walter F. One billion gallons of synthetic gasoline in 1918. 555
 Rogers, Allen. Recent advancement in leather manufacture. 524
 Rose, C. A. Metallurgy at Chile Exploration Co. (S.) 162
 Rosenthal, Harry. Coloring glass by short wave lengths of light. 677
 Roubleu, E., and G. Muntz. Steel foundry sand. (S.) 399
 Rue, John D., and Alfred H. White. Methyl alcohol and acetone from soda pulp industry. 182
- SADTLER, S. S. Nitro starch as an explosive. 361
 Schleicher, Henry M. Rapid analytical filtering. 548
 Schmidt, Herman B. Appreciation of Dr. Twitchell. 145
 Schwarz, M. V. Metallography of copper. (S.) 32
 Sebillie, Leo Paul. Generation of oxygen and hydrogen. (S.) 610
 Senglet and Briner. Researches on the carbides of aluminium, copper and nickel. (S.) 530
 Sherry, Ralph H. Grain growth in low-carbon steel. (S.) 224
 Sinnatt, F. S. Industrial gas burning. (S.) 455
 Smalley, O. Influence of arsenic on brass. (S.) 606
 Smith, James A. Determining density of flue gases. 160
 Sperr, F. W., Jr. Recovery of benzol from gas. 135
 —Recovery of benzol from gas. 301
 Steere, F. W. Producer gas and its industrial uses. 695
 Stenger, Edwin P. Exfoliation and carbon concentration in the case-hardening of steel. 425
 Strous, W. W. Some theoretical aspects of electrical fume precipitation. 648
 —Linn Bradley and H. D. Egbert. Construction of hot-blast stoves. (S.) 283
- TARR, H. G. H. Is not gas power cheaper than water power? 373
 Thompson, G. W. Human side of development of chemical industry. 149
 Thompson, Maurice R. Electrolytic oxidation of sulfurous acid. 178
 Thompson, M. de Kay. Electrolytic oxidation of sulfurous acid. 179
 —and C. N. Richardson. Brittleness of steel springs from electroplating. 83
 —and T. C. Atchison. Production and properties of magnetite electrodes. 605
- Thornton, H. M., and Harold Hartley. Melting of brass. (S.) 529
 Thum, E. E. Dedication of the Chemical Laboratory of the University of Cincinnati. 471
 —Cementation of iron and steel. 385
 —Albert Watson Davison. Metallurgy and electrochemistry at the University of Cincinnati. 367
 Tinker, F. Colloidal membrane. 680
 Furrentine, J. W. Carbonization of kelp for recovery of potash. 196
 Twitchell, Ernst. Perkin medal address. 142
- UHLER, HORACE S., and Philip E. Browning. Electrolysis of galvanic solutions. (S.) 163
- VAN MARLE, D. J., and A. H. Ney. Manufacture of intermediate products. 217
 Van Osbel, Edgar B. Potash possibilities in Oregon. 549
 Vom Baur, C. H. Rennerfelt electric furnace operation. 580
- WALTER, C. M. Melting metals with high-pressure gas. (S.) 529
 Walker, Kenneth C. Great library of applied science. 676
 Watts, E. E. Notes upon the hydrometallurgical and electrolytic treatment of zinc ore. 645
 Weber, Lothar E. Solvent recovery in rubber industry. (S.) 399
 Weems, J. B. Relation of research to everyday life. 478
 White, Alfred H., and John D. Rue. Methyl alcohol and acetone from soda pulp industry. 183
 Whittaker, C. M. Difficulties of the British coal-tar color industry in war time. (S.) 282
 Wiard, Edward S. Grading of graphite, gunpowder and malt. 654
 —Grading of crushed stone and gravel, feldspar, fireworks and flour. 449
 Williams, Richard G. The grinding wheel—a link between electric furnace and automobile. 599
 Wilson, F. B. Valency and valence. 12
 Wood, A. T. Use of rotary kilns for calcining lime. 402
 Woodward, R. W., and T. R. Harrison. Note on the thermocouple nichrome—constantan. 647
 Wysor, R. J. Potash from the blast furnace. 205
- YOUNG, S. W. Thiogen process for removing sulphur fumes. (S.) 309
 Y. X. Mexico—What will the final outcome be? 10

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Contents for January 1, 1917

EDITORIAL:

1917	1
"So Nice and Poor".....	1
Flotation Practice in 1916.....	2
Copper in 1916.....	3
Gold and Silver Metallurgy in 1916.....	5
Iron and Steel in 1916.....	6
Niagara Falls in 1916.....	7
Electrometallurgy in 1916.....	8
The Front Office.....	9

READERS' VIEWS AND COMMENTS:

Mexico. What Will the Final Outcome Be? By Y. X.....	10
The Recovery of Molybdic Acid from Phosphorus Filtrates. By E. W. Hagmaier.....	12
Valency and Valence. By F. B. Wilson.....	12
The Protection of Iron and Steel. By Henry Hess.....	13
A Chemist's Vacation. By Edward Hart.....	13
Coming Meetings and Events.....	15
The Western Metallurgical Field.....	15
The Future of the Iron Blast Furnace. By J. E. Johnson, Jr.....	17
Supreme Court Decision in Hyde Flotation Suit.....	21
Current Efficiency in Copper Refining. By Lawrence Addicks.....	23
The Nature and Origin of Petroleum and Asphalt. By Clifford Richardson	25
The Utilization of Waste Heat for Steam-Generating Pur- poses. By Arthur D. Pratt. Part II.....	27
The Production of Salt in Szechuen Province, Western China. By H. K. Richardson.....	32
Electrolytic Behavior of Tungsten. By W. E. Koerner.....	40
Stability of Paraffin Hydrocarbons. By Gustav Egloff and Robert J. Moore.....	47
Synopsis of Recent Metallurgical and Chemical Literature.....	51
Recent Chemical and Metallurgical Patents.....	53
Progress in the Use of Kieselguhr in the Insulation of Metal- lurgical Equipment.....	54
The Critical Point in the Heat Treatment of Steel.....	55
New York Meeting of American Institute of Chemical Engi- neers	55
Personal	56
The Chemical Market in United States in 1916.....	56
Market Reports—Iron and Steel, Non-Ferrous and Chemical.....	60
Industrial—Financial, Construction, and Manufacturers' Notes	63

Nineteen Hundred and Seventeen

The enormous prosperity which the chemical and metallurgical industries have enjoyed during the past year, cannot last unimpaired forever; it has been an integral part of the general industrial prosperity of this country and closely related to the international trade conditions brought about by the European war. When the war stops, there will come in this country, too, a period of industrial readjustments. Are the chemical and metallurgical industries as living organisms prepared for this radical change that must come some day? While in an economic as in a gastronomic sense it is bad to have "too much of a good thing," it can be said that in spite of their prosperity the chemical and metallurgical industries in the vast majority are in a thoroughly sound condition, that is in all essentials. As the many reviews of different industries throughout this issue will show, much has been accomplished in enlarging old and creating new establishments and industries. It cannot be expected that all of these will last. But in the larger new undertakings, at least, foresight into the conditions after the war has not been absent. What is needed now more than anything else is a sane, sensible legislative policy in Washington. There are some very discouraging signs—the pork barrel business, the coward stupidity with which the Niagara power problem is being handled, the attempt of penalizing publications of nation-wide importance for the benefit of local papers by new second-class matter rates. But there are hopeful signs, too; most shining perhaps the Tariff Commission soon to be appointed. And we may hope that, as so often before, the common sense and fairness of the American people will win out in spite of the politicians and find the right solution.

"So Nice and Poor"

She lives in a house in New York that is as big as a church and the annual tuition paid for her as a day scholar at school is a sum on which many a self-respecting family has been brought up.

She wanted to spend Sunday in the country with the Shorts. Now the Shorts are people of quality and merit, but not of circumstance. "Are you so fond of Hilda?" asked her father. "Oh," replied the daughter, with that integrity of youth which we have forgotten, "I like her well enough." "That is not convincing," he continued, "why do you want to go?" "Because the Shorts are so nice and poor," answered the girl.

There we have it. They are nice and poor. There are no butlers and second men, there is no governess or anything to disturb the spirit or hinder the flow of soul. The house is honest in its business of providing shelter and food for a family without a lot of uninter-

ested strangers about, earning their living by standing in everybody's way. A house where we can enter the kitchen and talk to the cook; where we can see what is going on. Jealousy and hatred and bickerings are things one can smell if he is young enough, and these things befoul the air of nearly every very big house. In a little one among those that are nice and poor there is no room for such things. A reasonable person, unspoiled by years and conventions, holds to the pursuit of happiness as is duly set forth in the Declaration of Independence. Some of us have forgotten it, and we take occasion, now that Christmas tide and New Year's Day are at hand, to preach a little sermon on the subject.

Few of us have the equipment of heart to fill a large house. We can fill it with vanity and fill it with show. The first is a gift that most of us can find by an inward glance, and the second is easily purchased. We can fill it with rules and with obedience, if we hold to the letter, but it is very hard to fill it with ourselves and have it a pleasant abode withal.

Most of us that are old enough can remember a house or so that was joyous that seemed big and was full of a great big man who was its master, but now-aways, if we look over those that are left, they seem surprisingly small. The modern big house is a palace, built in imitation of establishments designed for kings and queens, and these are next to impossible to fill with the spirit of good-fellowship.

We wish health and prosperity to all our readers. And then we wish them something more, something better and more valuable: that with prosperity may come such growth of understanding and sympathy as makes for the general welfare. There are side chains of antibodies that accompany every experience of life, and one of these is the very devil of vapid pomp, that jumps upon our backs as soon as the money comes rolling in. It spoils us and makes us little in the measure that we think ourselves big. We wish our readers deliverance of this evil and, in all prosperity, that quality of spirit which renders them "nice and poor."

Flotation Practice in 1916

The full effect of the application of flotation to various milling problems in North America has been felt during the past year. The call for increased production of all the metals was answered in some cases by installing flotation plants. In fact, we doubt very much if metal prices could have been held down as low as they have been if it had not been for the use of flotation in concentrating certain ores.

Practically every large copper company which is milling ores is now using flotation and thereby gaining simplicity and compactness in the mill flow sheets and also increasing the extractions over what was formerly possible. The simplifying and condensing of the mills has allowed greater capacities in the same floor space. By merely increasing grinding capacity through the switch from pebbles to iron balls, many companies are now producing almost twice the amount of copper formerly

concentrated, and often at a considerably lower unit cost.

One interesting point which has come up has been the actual testing out of large and efficiently operated mills where flotation was used as the major process. The Minerals Separation Company in years past has tried to get its clients to use flotation for the concentration of the ore with as little auxiliary concentrating apparatus as possible. They have claimed that the greater simplicity of operation gained by reducing the ore directly to the size necessary for flotation is worth the trouble. Of course, ores with more than one mineral, like zinc-lead ores, are exempt from this dictum. Minerals Separation was naturally interested in seeing as large a tonnage of ore treated by flotation as possible and other engineers have wanted to know whether this was the right flow sheet or not. The operation of the big new concentrator at Inspiration has done much toward answering this question, although there is still some doubt about just what it does mean. At Inspiration they find that they still have to operate tables on the flotation tailing, making 10 per cent of their total extraction by this method. Of course, the grinding leaves a considerable proportion of sands and there is also some "oxide" copper caught on the tables which would otherwise escape. As soon as the leaching of the flotation tailing is in operation, the total recovery on the tables could easily be much less. Tables do not cost much to operate and it is a question whether slightly finer grinding would cost more than the operation of these tables. So the Minerals Separation engineers were very nearly right and it may be that they will yet be fully justified. These considerations apply more nearly to large mills like the one at Inspiration than to smaller ones such as that of the Engels Copper Co., in California, where flotation is the only concentration process used.

It was thought for a time that flotation would be a serious competitor to cyanidation, when applied to gold and silver ores, but the general consensus of opinion now seems to be that it will be applied only to ores that are difficult to cyanide and that usually it proves to be a most useful adjunct to cyanidation. If the ore deposit being treated happens to be near a smelter, it is probable that the flotation concentrates will be smelted rather than reduced to bullion by the cyanide process. Otherwise flotation will be used on difficult ores to reduce the ore to a concentrated form, so that very careful cyanidation of a small bulk by highly specialized methods, such as that used in the "high grade" mills at Cobalt, may be practised. The advantages of shipping bullion from distant districts are such that cyanidation will probably not be abandoned unless methods of melting down flotation concentrate, such as those used for cyanide precipitate, can be invented.

With the ability to handle slimes, a return to machinery giving a maximum grinding effect for a given amount of power is being made. Only on ores that are incapable of flotation is the production of slimes still a curse. Crushing of ores for magnetic or electrostatic concentration must still take place in machinery that makes a minimum of slimes, and in tungsten concen-

tration the production of slimes and dust is also usually to be avoided, although one party claims to be able to float scheelite. It is probable that flotation methods will finally be developed to supplant such processes and on that account we look for magnetic concentration and electrostatic separation to be placed in more restricted fields than ever. In fact, with the zinc-iron mixtures, it is probable that the "magnetic" roast will be slightly prolonged to insure alteration of the pyrite, and that the material will then be ground and treated by flotation. This allows of higher extractions of the zinc and of the treatment of more disseminated ores. We are surprised that the companies treating the more complex sulphides in the Western mining states have not adopted this method of separation. For some time there has been known to be available the Horwood process which gives the finely ground ore a flash roast enough to alter the surfaces of the pyrite particles while sphalerite is unaltered, but the roasting of fairly coarsely ground ore, to alter the pyrite deeply enough to allow fine grinding in water just before flotation, removes the objections that were raised to Horwood's process, which required a dry but finely ground feed to the roasters, a thing usually difficult to obtain. Further, as far as we know, it is not a patented process.

Grinding machinery is not the only mill machinery to be altered. Flotation machinery itself has seen a remarkable development during the year and the announcement of the Inspiration machine, the Cole-Bergman, the Kraut & Kohlberg, the Jones-Belmont, the Parral, etc., have appeared and a new type of Janney machine with "air baskets" in the spitzkasten has also made its appearance. Some of these machines have not been designed merely to avoid payment of patent royalties, as some of them quite frankly are, but there is a real advance in the art and some of the mechanical improvements are quite ingenious. The saving in power which some of them allow is considerable and the limit has not been reached. The question of saving power is now quite commonly considered, and it is recognized that where the flotation oils can be added to the ball mills before the pulp reaches flotation, the oil is not only well distributed but increased extractions are sometime possible. Where the oils are added ahead of the ball mills there is very little "agitation" of the pulp necessary during flotation and pneumatic cells of one design or another are probably the logical machines to use under these conditions. Would that patent litigation could cease and the real truth about the benefits of different systems of flotation be made available!

The year has seen the installation of several "sulphidizing" and flotation plants for the treatment of oxidized ores of base metals. At the time of writing oxidized copper is being floated by means of hydrogen sulphide sulphidizing at the Magma mill in Arizona, while lead carbonate ore is being floated by the use of sodium sulphide as a sulphidizer at the Prince Consolidated mill in Nevada. A number of other companies have experimental mills under way. The importance of the treatment of oxidized ores is almost impossible to estimate. The use of small units on such ores will al-

low of the treatment of the oxidized ores on the outcrops of many properties through Nevada, Utah, Arizona, New Mexico, Colorado, Idaho, Montana, Washington, Oregon and California. In these states are thousands of prospects whose outcrop ores are often too low-grade to ship. Flotation of the oxidized ores will allow of their being developed at a profit and besides a flotation mill will treat the sulphide ore which is reached with depth. The further development of processes to treat these ores is hence anxiously awaited.

The flotation process has come to stay. Already it is being used in the treatment of well nigh 150,000 tons of ore daily in North America, and there is believed to be enough new work on foot so that the tonnage will be doubled in about five years.

At the beginning of 1916 the situation in obtaining a supply of flotation oils was somewhat acute. While it is still hard to get all the oils wanted, many of the mills have now found supplies of material with which they can operate, although the most desired materials are sometimes hard to get. Coal tar and creosote from practically all of the intermountain gas plants has been contracted for and much material from the Middle West is now being used. Sage brush oil has been found to be an excellent flotation oil, and a movement is now on foot to distill sage oil from some of the larger "forests" of Idaho, Utah and Nevada.

The Year 1916 in Copper

The year 1916 was one of unprecedented prosperity for the copper producers. The price of the metal increased from 18 cents per pound at the close of the previous year to 33 cents at the close of the past year. So great is the demand for copper that it is estimated that nearly all of the production for the first half of 1917 has been sold at prices around 30 cents per pound.

It seems likely that this condition will continue for the duration of the war in Europe. The end of hostilities will probably cause a decided diminution in the demand for copper; at least until such time as a readjustment can be effected and the reconstruction period is actively under way. Although the shipments of copper from this country to Europe have been larger than ever before, England and France have both been forced to cut heavily into accumulated stocks.

Stimulated by the extremely high prices the copper companies have made every effort to increase their output, and have in most cases succeeded in adding anywhere from 30 to 50 per cent to their production. The Anaconda Copper Mining Company produced about 340,000,000 lb. in 1916 as compared with 235,000,000 in 1915. The Utah Copper Company produced about 225,000,000 lb. in 1916 as against 148,000,000 in 1915. Similar increases have been made by Chino, Ray Consolidated, Granby, and others.

Inspiration has been brought into the producing stage to such good effect that its average production per month for the year was in excess of 10,000,000 lb., and at the close of the year it was producing about 11,500,000 lb. per month. This company has probably

the most modern and up-to-date mining and milling plant in existence. The automatic hoist is a source of wonder to everyone who has seen it. It is astonishing with what smoothness and ease the enormous output of 18,000 tons per day is raised by this equipment. The Inspiration concentrator was the first large copper plant to be put entirely on a flotation basis, and it has been an unqualified success. While tables are in use they merely serve to catch the few coarse grains of mineral which may have dropped back in the flotation machines. Large drag-belt classifiers are used between the flotation machines and the tables for the purpose of desliming the feed to the tables. Experiments, however, have demonstrated that these classifiers are hardly needed, as the work which the tables are called upon to perform would be done equally well without them. It seems to be generally conceded that the scheme adopted by Inspiration of following the flotation machines with tables instead of preceding them is the better practice where the ores undergoing treatment contain the copper minerals in a finely disseminated form and where the concentration ratio is large. The flotation machines catch the fine mineral equally as well in the presence or absence of coarser mineral, and in view of the fact that they operate on a denser pulp than the tables, the arrangement adopted at Inspiration eliminates a lot of dewatering apparatus which would otherwise be needed.

At Anaconda conditions are widely different; here there is an ore containing about four parts of iron for every one part of copper, with the result that the concentration ratio is only three into one. Moreover, the mineral is so coarse that over two-thirds of it can readily be removed after grinding to 2 mm. The coarser table concentrates are so much easier to handle in the smelter and the dust losses are so much less that it would be obviously unwise to grind everything to flotation size before commencing concentration.

The remodeling at Anaconda was completed during the year, and the entire reduction works are now operating on the new basis. The plant has produced in excess of 27,000,000 lb. of copper per month for several months. The normal monthly output is between 25,000,000 and 26,000,000 lb.

The coal-dust fired reverberatories and the 20-ft. Great Falls converters have proved an unqualified success, although from last accounts it appears that the prestige of the latter is likely to be somewhat diminished by the new Smith-Pierce converter at El Paso, which is of exceptionally large size and improved design.

The No. 2 roaster plant, which contains twenty-eight 25-ft. Anaconda-Wedge furnaces, has proved a complete success, and the furnaces are roasting concentrates containing 33 per cent sulphur down to 7 per cent at the rate of 150 tons per day each.

A problem of continually increasing importance to the copper and lead smelter is the prevention of damage to the surrounding country by means of dust and sulphur dioxide. Very little has been done with regard

to the latter except so far as this can be accomplished by dilution of the gases. The precipitation of dust is being effected in several places by means of the Cottrell treater, which under favorable conditions is capable of producing excellent results. At the new smelter of the International Smelting Company at Miami, which treats the concentrates from both the Inspiration and Miami concentrators, Cottrell treaters are used at both roaster and converter plants. At the former the treaters are mounted directly over the furnaces and no dust chamber is used. The installation has been very successful, and the perfection with which the entire smelting plant does its work may be judged from the fact that its recovery is in excess of 97.5 per cent of the copper contents of the concentrates.

The advent of the Chile Copper Company among the ranks of copper producers during the past year has been an event of exceptional importance, partly on account of the huge size of the ore deposits, which will probably eventually result in the enlargement of the reduction plant to a size hitherto unapproached, and partly on account of the fact that this is the first large copper property to depend exclusively upon an electrolytic leaching process. While difficulties have been encountered in starting this plant, nevertheless the production of copper during the past year has been fairly satisfactory and the outlook for the future is very good indeed. The process has been demonstrated successful and the difficulties which remain to be overcome are mostly mechanical.

Work has been pushed as rapidly as possible on the leaching plant of the New Cornelia Copper Company at Ajo and is nearing completion. It is expected that the plant will be making copper in February. The process used has been fully described by Dr. Morse and Mr. Tobelmann in the Transactions of the American Institute of Mining Engineers, and is along the same general lines as that used by the Chile Copper Company. There is, however, no chlorine in the ore, and very little in the water, so that it is unnecessary to use the dechloridizing drums, which are so essential a part of the plant at Chuquicamata. It is the intention to use sulphur dioxide for controlling the ferric iron in the solutions at Ajo.

During the past year a rather unusual condition has developed in that the production of blister copper threatened to overtax the refining capacity of the country. This was foreseen, of course, and large additions were made to most of the refining plants. A new refinery was constructed by the A. C. M. Co. at Great Falls capable of a monthly output of 15,000,000 lb. This plant is up to date in every respect, and makes use of a current density rather larger than is customary in the East, viz., 22 amp. per square foot.

Owing to the low-priced hydroelectric power available, calculations showed this to be the most economical current density at which to operate when all things, including fixed charges on the investment, were taken into consideration. This plant has been operating steadily since last March.

Gold and Silver Metallurgy in 1916

The gold metallurgist has given but divided attention to metallurgical progress during the year. He has been actively occupied with the problems arising from the upward trend in cost of the supplies required for producing his finished material, which, almost alone among commodities, has not appreciated in value. Prosperity has passed him by. He is the mourner at the feast.

Such unsettled market conditions, though responsible for many present inconveniences, hold some promise for the future, through the development of American sources of supply. Thus cyanide of American manufacture has entirely replaced the German product, and it may be said that in quality and uniformity it is equal to the best heretofore imported. Potassium cyanide has quite disappeared from the market, without ill effect on the output of American mines. Incidentally, we note with satisfaction that the manufacturers have ceased to refer their analyses to the potassium cyanide standard, and are quoting the content of sodium cyanide—certainly the only rational classification. If operators will follow this example and finally discontinue reference to "128 per cent cyanide" and kindred absurdities, the cause of precision, at least, will have benefited.

Silesian zinc-dust, formerly the best material available, has been unobtainable since the early months of the war, so that operators have now two years' experience with the American dust. This, at first greatly inferior, has been improved until from at least one source is obtained a dust even superior to the best Silesian grade. The advance in price has stimulated investigations directed to the improvement of precipitation methods and of precipitants, and it is probable that interesting developments in this branch of cyanidation may be expected within the current year. In this connection the recently reported preparation of electrolytic zinc dust is of interest.

Another step in conservation, due to the impelling force of rising prices, may be noted in recent practice at the Homestake, where certain classes of precipitate are retorted for the recovery of the quicksilver content, prior to smelting for gold and silver.

The silver metallurgist passed, in the meanwhile, through much the same experiences. At the nadir of his fortunes a year ago, he has been relieved during the past eight months by a strong market for his metal, so that for him the burden of war prices has been lightened.

The Cobalt district witnessed tremendous appreciation in the cost of aluminium dust and of sodium hydrate, both of which are largely used in the processes more or less peculiar to that district. Perhaps the most striking feature of recent work there is the increasing attention being given to the salvage of minor metals in the ore.

Steady progress has been recorded in the application of flotation to the metallurgy of gold and silver. At Goldfield and in the San Juan plants are in successful operation; at Cripple Creek and Cobalt the process is

receiving attention as a means for the beneficiation of difficult ores. A consideration of the ores under treatment in these districts—copper-bearing sulphides, mixed sulphides of lead, zinc and iron, tellurides and arsenides—indicates clearly the field best suited for its application. It is our impression that the year has done much to establish the practical limitations to its usefulness.

Ores relatively amenable to cyanidation, not requiring roasting or other preparatory treatments and containing no metals of secondary but commercial value, offer little opportunity for flotation to displace established methods. When in such circumstances the newer process is favored, it may be presumed that because of small ore reserves or limited capital unusual stress has been placed on the smaller initial cost of plant. This, one of the strong claims of flotation to consideration, is offset by the fact that it is not a complete process, but must depend on smelting or other subsequent treatment for the final recovery of its metals in marketable form. In the development of the flotation process the equipment of the cyanide operator has been drawn on freely, and several devices, notably Door and Oliver machines, have become standard equipment in the flotation mill.

New mill construction indicates that the gold-mining industry has generally accepted the crushing methods of modern copper mills. The Alaska-Gastineau has scored a sound technical success in its milling operations, however its position marketwise has been affected by the disappointing developments in the mine.

The first successful application of the ball-mill to gold ores was made, we believe, at the Vipond. Now we hear that these mills are to be installed at the Dome, displacing stamps of comparatively recent design. This advance seems reasonable, and we look for its continuance. Too much stress has always been placed on the supposed simplicity of the stamp. The past generation of engineers often spoke of "muscular metallurgy." The phrase was probably coined by a stamp-mill operator. As an amalgamating device, the stamp is pre-eminent, but complete recovery by this means is seldom attempted in these days, and it is probably sufficient thus to care for the coarser particles of gold.

It is to be regretted that published data of ball-mill performance have generally failed to take account of the accessory crushing machines which must both precede and follow it in the flow-sheet if it is to duplicate the product of the stamp. Among these data of crushing, the recent paper by Blickensderfer, in which a test of the Marathon mill is described, is of more than passing interest. This mill is a competitor of the ball-mill, but carries a charge of steel rods instead of balls. The fact that the marathon mill was compared with that of a pebble-mill, instead of a ball-mill, perhaps accounts for the remarkably good results, which are difficult to understand at first glance. Students of the mathematics of crushing should analyze for us the forces acting through this mill, of which we shall doubtless hear further, as the reported results indicate that the machine has a future.

In mill design other than crushing, the trend to

counter-current decantation has continued, at the expense, in great measure, of the basket types of filter. Thickeners of the tray type are proving very valuable. At the Liberty Bell, crucible smelting of precipitate, with preliminary sintering, has been put upon a rational basis. Weinig's description of the method merits consideration, particularly from the operators of relatively small plants.

Iron and Steel in 1916

The "prince or pauper" industry outdid itself in 1916. It became a prince in 1915, but what title to give it for 1916 we do not know. It was not a dictator, for it is commonly said that the tremendous price advances that occurred were brought about by the buyers, not the sellers, through the buyers importuning the mills to place their orders on books, even going to the length sometimes of requesting that the orders be entered and the price be set against the tonnage when it suited the convenience of the mill. "Delivery at mill convenience" became a common phrase in market reports.

Using weighted averages, the advances in pig iron per gross ton and in finished steel per net ton, have been as follows:

	Pig iron	Steel
1915	\$5.50	\$13.00
1916	11.00	29.00

Steel prices reached by the end of 1915 represented the traditionally "safe" level, the level attained in 1907, but not reached in the advancing movements of 1909 or 1912, though they were substantial and satisfactory movements in their time. Immediately, or as a matter of fact on Jan. 6, 1916, there was published the "stop, look, listen" statement of Chairman Gary of the United States Steel Corporation. Whether he expected his advice to be heeded, or merely wished to wash his hands of responsibility for what should occur thereafter, is not known. At various times in the past the Steel Corporation has applied the brakes, as it has sometimes also supplied an accelerating influence.

Steel price advances in 1916 were most rapid in January, February and March, and in August to November inclusive. There was almost a lull between times. The market showed its usual signs of possessing inertia, whether static or kinetic. Circumstances were such as to arouse some suspicions that an advance in steel bars made Aug. 1 by a prominent steel company represented an effort to get things started again. The bar market has shown some indications of weakness in July. If it was an effort, the effort was successful.

The 1916 advance in steel products brought prices late in October level with the top prices reached in the "boom" of 1899, but the prices taken for 1916 are prices for delivery at mill convenience, while in 1899 there were no such prices, the market being substantially a premium market. Prices advanced nearly \$10 a ton more, at any rate, and all that was clear space on the chart of prices for the steel industry's whole history, covering a period of only about a quarter century, as it was early in the decade of the eighteen-nineties that

mild steel supplanted the product of the puddling furnace as the dominant rolled product. Rail carbon steel had, of course, replaced wrought iron for rails much earlier, but it offered a vastly superior commodity, beyond question in any quarter. Comparing steel bar prices at the end of 1916 with historic iron bar prices, one finds as high prices, or higher, only from September, 1879, to April, 1880, and in various periods prior to the spring of 1874. The high priced period which ended in 1874 has lasted for about a decade.

We estimate production in 1916, in gross tons, as follows, compared with previous records:

	Estimate 1916	Former Record
Pig iron	39,400,000	30,956,152 (1913)
Steel ingots and castings.....	42,500,000	32,151,036 (1915)
Rolled steel	30,500,000	23,112,986 (1913)
Rolled iron	1,500,000	1,678,257* (1913)

*Surpassed in various preceding years. Record unknown.

Pig iron broke its former record by 27 per cent, while steel ingots and castings broke their former record by 32 per cent. The divergence was due partly to the iron founding industry being not proportionately as busy as the steel industry in 1916, and partly to the fact that owing to the manufacture of a large tonnage of shell steel, with heavy discards, there was more scrap available and less pig iron was needed. The proportion of rolled steel to ingots produced was lower in 1915 and 1916 than in normal years, for the same reason, and as 1915 was not a sure criterion of the disturbance in proportions produced the estimates for 1916 must be taken with a larger allowance than is usually necessary. Approximate estimates are useful as the official statistics will not appear for months.

Not a single new blast furnace was blown in during 1914, and there were only three for 1915. As only 31,000,000 tons of pig iron had been produced in 1913, although the industry ran substantially at capacity through the first ten months of the year, there was a disposition to rate the actual productive capacity, at the close of 1915, at not more than about 35,000,000 tons. Although only two new furnaces were blown in during the first half of 1916, and only one or two in the second half, the actual production exceeded the estimated capacity by more than 10 per cent. This performance is attributed chiefly to changes made in the lines of many furnaces, chiefly by way of enlarging the hearth, though progressively harder driving year by year, and minor improvements, have played their part.

The excellent performance of the blast furnaces averted the pig iron famine that had been predicted for the early part of 1916. It had been noted for a number of years that steel works capacity was increasing much more rapidly than blast furnace capacity, measuring the latter merely by the number of new stacks. It was about June, 1915, when the market movement was still in its infancy, that the first announcement was made of any fresh increase to be made in steel making capacity. Afterwards the new projects came thick and fast. Fully 3,000,000 tons of steel ingot capacity was added in 1916, and there would have been more had not construction work proceeded so slowly. There is fully 4,000,000 to 5,000,000 tons of capacity now under construction or

definitely projected, with almost as large a tonnage of blast furnace capacity.

The perennial question has been "Where does all the steel go?" This question has been asked in times of depression, when there seemed to be no demand at all, for in the poorest steel years the output has exceeded that of seven years earlier, and usually it is asked also when demand is heavy. In 1916 "war demand" appeared to most observers to furnish an adequate explanation, but that was hardly the case. The rolled iron and steel exported directly, or consumed in the manufacture of everything that was exported, railway rolling stock, machinery, loaded and unloaded shells, etc., was approximately 8,000,000 tons, or 25 per cent of the production. In 1912 and 1913, the best export years, the proportion of export material was about 11 per cent. The remainder, for purely domestic consumption, was about 22,000,000 tons in 1912 and 1913 and 24,000,000 tons in 1916.

In some quarters the domestic consumption was relatively light in 1916. Cars and locomotives ordered in 1915 and 1916 were much fewer than in several of the earlier years, when the steel making capacity was much less. Monthly reports of the Bridge Builders' and Structural Society showed average bookings in 1916 representing 70 per cent of the fabricating capacity, distinctly a poor record. The production of galvanized sheets was very light. The production of rails for domestic consumption was much less than in 1912 or 1913. The consumption of the ordinary every-day commodities, the things the people at large use, as distinguished from consumption by the railroads and consumption in great construction works, must have been very much larger than in any preceding year. There was a reason for this. Most of the people had plenty of money, while the capitalists did not care to invest heavily, against the prospect of future earnings, at a time when materials and labor were extremely dear.

This analysis naturally suggests the future. By the middle of December the iron and steel market had slowed down, had almost come to a halt, due probably to a combination of circumstances rather than to the single incident of Germany making a peace overture. There is more interest in the future. The present appears to be a case of filling the large mass of orders on hand, with the country's transportation system in very poor working order, car shortages almost everywhere and embargoes without number.

After the war, whenever that period starts, there will be different prices, prices more or less in keeping with the conditions expected for a number of years. Projects long deferred will be launched. The past three years, at least, have constituted a period of very light new construction, and requirements have banked up.

Niagara Falls in 1916

To those who realize the intimate relation of electrochemistry to our daily life it is no matter of surprise that the past year was one of extraordinary activity in Niagara Falls and that its development as the greatest

electrochemical center in the world reached a maximum. Not one of the electrochemical factories at Niagara failed to feel the stimulation of the increased industrial activity throughout the country.

It would be difficult, perhaps impossible, to say what particular industry was affected most. A mere study of prices would at once show what the conditions were as regards products like aluminium, ferroalloys, chlorine, etc., but there are other products in regard to which prices do not give any indication of the extraordinary developments, such as abrasive materials, graphite and carbon electrodes. Nor again would the price list show the new plants started at Niagara Falls.

There is perhaps a tendency to believe that this great activity in electrochemistry has been mainly due to war orders, perhaps because of the considerable popularity given to accounts of the importance of electrochemical products as a factor in national defense. However, while a certain percentage of Niagara Falls products in 1916 may be classed as direct war orders, the great bulk of the increased production was only related in an indirect way to the war. It would, of course, be folly to pretend that the enormously increased prosperity enjoyed by the electrochemical industries was normal and would have existed quite apart from the war; but it is true that the greater part of it has not been due to mere war orders, but was simply inevitable because of the general increase in prosperity throughout the country.

The truth is that there is no industrial center in the country which is more intimately associated with the daily life of every man in the United States. The laborer, the farmer, the clerk, the banker, in fact every simple inhabitant of the United States, is closely dependent on the electrochemical industries of Niagara Falls every moment of his life from the time he leaves his bed till he returns there at night. Unfortunately this dependence on electrochemical products is by no means realized by the man in the street. He does not know that in his every-day life there is hardly a moment that he is not using something directly or indirectly a product of the electrochemical industries, and that the production of this product depends on the utilization of what he has been taught to believe is a great "national spectacle" of right belonging to him, but threatened by a mysterious monster called a Power Trust.

We have said that the Niagara Falls industries have reached a maximum because it is now too plain that the curve of progress must become a horizontal line or even deflect downwards. With the increased production of electrochemical products in 1916 there has been a corresponding increase in the demand for power and long before the close of the year the limit allowed by the so-called Burton Act was reached. True the Burton Act was dead and the power of granting further diversion of water was in the hands of the Secretary of War; but unfortunately he was doubtful of his right to exercise the power, and his doubts were probably strongly reinforced by the fear of popular

superstitions deliberately fostered by unscrupulous propagandists.

The serious situation resulting from the power shortage was further increased by the demands of the Canadians. Here, too, there was an enormous increase in the demand for power in 1916 and the government was asked to exercise its right to cut off the supply of power exported from Canada to the United States.

Thus, while the year 1916 has witnessed a wonderful growth in the Niagara Falls electrochemical industries of which the country may be justly proud, it has also presented the sad spectacle of this great and beneficial development threatened with arrest largely for the purpose of keeping a Harrisburg printing press busy.

Electrometallurgy in 1916

During 1916 there has been a greater commercial development of electrometallurgical industries in the United States than at any time during recent years. What we said of the Niagara Falls electrochemical industries—that their immense activity and prosperity simply reflected the broad industrial activity of the country—is also true of electrometallurgy, and again in this case some direct influences of the European war are easily discernible. The heavy consumption of alloy steels formerly made largely in the crucible, the increased demand for ferro-alloys caused by the greater production of alloy steels, the shutting-off of imports of ferro-alloys and other electrometallurgical products, like aluminium and magnesium, the high prices of metals permitting experimentation with new processes—all these are contributory causes of the recent industrial advance in electrometallurgy.

After the installations of electric steel furnaces in this country had approximately doubled in 1915, the progress of the electric steel furnace has continued at almost undiminished rate in 1916. The chief trouble met with is a lack of experienced operating men. But high-speed tool steel is now being manufactured in 6-ton heats as a regular procedure, in contrast with the 100-lb. pour of the crucible. The heavy demand for high-speed tool steel and the difficulty of securing crucibles at any price has made the electric steel furnace an economic necessity, and it is here to stay.

A considerable number of electric furnaces have been installed in foundries for the manufacture of steel castings. More installations are contemplated involving the use of the electric furnace in a duplex process with the open-hearth or the converter. Several electric furnaces are melting ferromanganese before addition to steel.

In Germany—formerly the largest producers of electric-furnace steel—the heavy demand for tool steel has also resulted in an increased use of the electric furnace for steel making. In August the production reached 17,000 tons per month, or six times the monthly production at the outbreak of the war. On the other hand, the production of crucible steel in Germany has remained stationary, there being no new installations of any size. The monthly production of electric-furnace steel in Germany is now double the crucible output.

On a smaller scale there has been a heavy increase of ferro-alloy manufacture in the United States. Three new manufacturers of ferrosilicon started production during the year. At the outbreak of the war about half of the domestic ferrosilicon consumption was imported, but now practically all ferrosilicon needed for consumption is manufactured here, and a small amount is being exported. To provide part of the needed furnace capacity a calcium carbide plant in Niagara was switched over to ferrosilicon manufacture. During the period in question the domestic consumption of ferrosilicon has doubled and is estimated at 45,000 tons annually.

The largest domestic producer of ferrochrome was able to supply the increased needs of the steel industry, but it is probable that if this producer had not carried large stocks of foreign ore, there would have been a shortage of ferrochrome. The development of California mines has been slow and the average grade of the chromite was too low for alloy manufacture. With other alloys, such as ferrotungsten, ferrovanadium, ferrotitanium, and ferromolybdenum there has been an increase of production and several plants have been established. There is now sufficient plant capacity in this country for filling all domestic requirements of ferrotungsten, and for the first time considerable quantities of ferrotungsten are being exported. Exports of ferrovanadium have doubled since 1915. Most of the new producers are using the electric furnace. Ferrotitanium is produced at Niagara to the limits of plant capacity and the demand is greater than the power supply. A fair quantity of ferromolybdenum is being manufactured in the United States, and toward the end of the year there was a marked increase in demand for foreign shipment which is believed to have to do with the lining of big guns. Ferro-uranium was produced commercially for the first time in this country, and may be added to the new products of the electric furnace.

Aluminium manufacture in the United States enjoyed in the past year undoubtedly maximum production and maximum prosperity in its history, the lead over European producers being increased. The North Carolina plant of the Southern Aluminium Company, which in 1915 passed into the hands of the Aluminum Company of America, is expected to start operation in the near future. Further large projects for increased plant capacity are under way. The imports dropped to about one-tenth of the normal quantity and exports doubled. There are no new producers besides the Aluminum Company of America, up to the present. J. W. Richards, perhaps the best connoisseur of aluminium metallurgy, estimates that by 1925 aluminium will be third in importance among metals (measured by weight), and will be outranked only by copper and iron. This is an interesting prophecy, and a safe one, too, as 1925 is sufficiently far off. Qui vivra verra.

As a result of operations started in 1915 several plants are producing on a small but commercial scale by electrolysis very pure metallic magnesium.

Among new electrometallurgical enterprises electrolytic zinc looms large. There is the electrolytic zinc

plant of the Anaconda Copper Company at Great Falls, Montana, with a production of 100 tons of electrolytic zinc per day, while as a result of the Bully Hill experiments of the General Electric Company a \$350,000 electrolytic zinc plant is being erected at the Mammoth smelter in California. As in 1915, there was in 1916 practically no development of electric-furnace smelting of zinc ore, so that in a time most opportune for commercial development nothing has been accomplished. It would seem that electrolytic zinc has the upper hand, and may be able to keep it, although in a measure its sudden development to a commercial process has probably been accelerated by the facilities of the Anaconda company available for placing an experimental development on a commercial basis.

The electrolytic copper refineries that were hit so hard at the start of the war have all been working to the limit of their capacity. Electrolytic refining has also made a success with tin; for years we have heard from European tin producers that Bolivian tin ores would always be out of question as the tin produced would be too impure; the success of the combined tin smelting and electrolytic refining plant of the American Smelting & Refining Company at Perth Amboy has proven that the additional refining cost is by no means prohibitive, and the only reason why enlargements have not yet been made is the present high cost of building materials. The plant is to stay and to grow.

The Front Office

He is a successful chemical engineer and is called upon for advice by the great and powerful. Neither contact with the affluent nor his need of a larger safe-deposit box for his growing bundle of securities has turned his head. Success has mellowed him, made him more thoughtful of the general welfare and caused him to grow in grace and amiability.

It was at the end of a long and very hard day. "I think," said he, "that if I had the administration of a great corporation in hand, I should ask for a special appropriation of ten thousand dollars a year in order to provide two five-thousand-dollar men. And I should put one out in the front office to meet visitors as they come in and the other should answer the telephone. I think it would be a profitable investment.

"Lately I wanted to buy some property. One of the big corporations with stock duly listed on the Exchange owned a factory site for which they had no use and which they were anxious to sell. It was just about what I wanted. They had been trying to sell for several years, and I doubt if many bids had been received. So I went to see them. Now I do not set up to be Phoebus Apollo or Hermes, or even a handsome man, but I do not think I look like one bent on robbing safes. Yet if I had been a tramp or a yegg I could not have received a less cordial reception. There was a very glib young person in attendance who acted—no matter what he thought—as though his chief duty was to get me to go away. He did not know anything and could not understand explanations. In vain I urged him to bring me into communication with an officer of the company.

My reasons did not satisfy him. Finally I broke through his barrier and went inside, just a little flustered, but not too nervous to lower my bid. They were still very anxious to sell, and were very glad to see me. But why insult me on the way to see them?

"Again, the other day, I was in the market for a product that just now is produced in large quantities, but most concerns are sold out ahead. I called up one of the chief producers, gave my name, and asked as politely as I could. They know that I am often in the market, so it would seem that I ought to be a welcome guest sometime in the future. I explained what I wanted and what deliveries I needed, but 'Sold out. Nothin' doin'. Click,' was the answer that I received, and the last word, click, was a noise made by hanging up a telephone receiver; it was not a spoken word. I do not want them to kowtow before me, but I do like a rather full answer to questions. Rebuffs like that upset me and make me want to avoid communicating with them again if I can help it."

The fact is, the front office needs reorganization in a great many establishments. The men in authority are busy and do not want to be bothered. The ill-paid homunculus that sits at his desk outside the inner sanctuary does not want to disturb them lest he incur their ill favor. But the man from without bringing good will and business is put through a distressing initiation before he can enter the sacred portals of the place where goods that he may want to buy are for sale.

The front office homunculi or the elderly dunder-heads in buttons and the braying asses at the telephones may all be useful animals, but they are not in their right places.

They should be supplanted by men (or women, for it's brains, not sex, that we are discussing) who are polite in their minds, who are able to apologize with grace to the man whose temper is undergoing exhaustion by long waiting, and they should know enough about the business to save half the waiting now necessary.

If we were to give the names of the great and otherwise well-managed concerns which maintain a veritable Bureau of Insult in their front offices and at their telephones we might easily be sued for libel. The captains of industry, at their desks a few doors away in the same offices, seem to use up all the politeness in their commercial servants. They are not aware of the naughtiness with which they even up their self-esteem upon visitors.

The small buyer, whose needs are as important to him as are those of the thousand-ton man, has no chance at all. When the war is over he will go back to the importer. The importer will make him welcome, and the small buyer will not find a single big head in the importer's office during business hours.

Politeness coupled with ability is scarce and expensive, but in the case of young persons who have the ability but not the gift of gracious bearing, there used to be methods current to put what was termed the fear of God into their hearts. It might be well to revive the custom.

Readers' Views and Comments

Mexico—What Will the Final Outcome Be?

(From an American Engineer, for Years in Mexico.)

To the Editor of Metallurgical & Chemical Engineering

Sir: What will the final outcome be in Mexico? This is an interesting question to many people, though not to any large proportion of the American people. To us Americans in Mexico who have material interests the question is not only interesting—it is important. Whether our going there to carry on business was an offense against public morality or not, the cold fact that our money and our properties are tied up there concerns us vitally, and we wonder what we can do toward conserving our interests.

It is impossible to discuss the commercial aspects of the case without bringing in the political aspects. There has been as much political bungling of relations with Mexico as there was between Bulgaria and the Entente Allies—which permitted Bulgaria to take sides with the Central Powers. Mexico has wanted for years to get on a friendly footing with the United States, and Americans who have gone into Mexico during the last ten or fifteen years have done their best to convince the Mexican that that old feeling of distrust toward Americans was unwarranted and uncalled for. It has worried the Mexican to see all the commerce and the active industries of his country going into the control of foreigners; and he has had an innate fear that some day the material influence of the domination of commerce would lead to the desire to exert a corresponding influence in political affairs. So he has distrusted the foreigner in general, and has singled out the American in particular mostly because of personalities.

When we pin down any Mexican to tell us what the real fundamental causes are or have been for the universal feeling against Americans more than against other foreigners, he is hard put to explain himself; he must speak of personalities, and his delicacy makes him hesitate to speak out. He will admit that any American-managed institution will operate in conformity with the laws of the country, will pay its employees better wages, will give them more hospital services, and more schools for their children, and will abstain from mixing in politics more so than concerns managed by other foreigners. Then what is the trouble?

Well, says the Mexican, you do not understand us personally, our customs; you look down on us with scorn, and force on us your beliefs that we are an uncouth, undesirable people, not to be considered your equals in any phase of life. You show it explicitly in that you will not intermarry with us. All other foreigners will marry here, but the American, as a whole, seems to have decided scruples against it. On our side, we think that Americans are brusque, blunt, cold-blooded, too clever for us in business, impolite, lacking in culture and refinement.

The American in Mexico realizes the handicap under which he labors in that the Mexicans as a whole have an aversion to the Americans as a whole, so he endeavors to overcome it by patient, tactful manner in his dealings with the Mexicans. But it is against the lifetime customs of the American to have to use the special tact needed in Mexico; at home he uses special-delivery mail, the telephone and the telegram to expedite his business with brusqueness and rapid-fire decision; this bores the Latin-American at every turn. So

many an American in Mexico makes but a sorry mess of it, and usually makes himself more disliked than ever. The Americans who have been a long time in Mexico have improved themselves in this detail; their experiences have taught them to do it. But the newcomer and the people at home show no improvement.

"Foreign policy" is a term or expression as foreign to the mind of the average American as is the term "tact." At home we think the sun rises and sets around our good old United States; all foreign peoples should learn our language and should be glad to have our business on our own terms. The American who goes to a foreign country condescends to learn about as little of the language of that country as is absolutely needed still to bat around at his business, comprehending little and miscomprehending much of the language, ways and customs of the natives.

So the average newspaper writer, associated press correspondent, confidential agent, personal spy and all of the ilk, are as competent to understand the Mexican question and to write reports on it as would be some Hungarian journalists that could speak no English and had never been in the United States, should they be sent over to write up the negro question of the South.

Porfirio Diaz knew that Mexico's natural resources would never serve the upbuilding of the country if native capital were to be depended on for the exploitation. He deliberately planned and carried out a program that induced the coming of foreigners and of foreign money into the country. Among the foreigners were many Americans. Foreign governments at the same time materially aided their nationals to come to Mexico to do business. Among these foreign governments the American government for thirty years encouraged its nationals to go to Mexico. The United States Federal government has brought about the building of the Pacific railways by the scheme of granting lands and other natural resources to the railway builders. The time for the necessity for such measures has passed, but there was a time when it was necessary. Mexico also has aided the building of railways by using the same plan. In the States we spoke of "land grants," in Mexico they are called "concessions."

To-day, in the States, when some corporation looks over the field for an opportunity to set up a factory of some kind, all the towns in the territory considered get busy and offer free land and tax exemption in order to secure the location of the factory. The scheme is considered honorable and to be commended. When Porfirio Diaz wanted cotton factories built up in Mexico he followed the same plan, but our American people and our home government qualify those acts of his as acts of giving away the country's resources, and the factory builders are called concession hunters and public grafters, and it is argued that these people should ask for no sympathy should they lose their interests later on.

I have lately been in middle Pennsylvania, and I observed many silk mills, all owned by one parent company in Germany. The mill managers and superintendents are German; many of their skilled operatives are German. Every new mill installation receives free or nearly free land for building sites; all have received tax exemption. Did Germany's home government encourage the building of these institutions? Did she discredit her citizens because of their enterprises? Does the American government encourage such build-

ing, and does it, or do the American people discredit these Germans because of their coming over here to do business?

Then why are we Americans of Mexico so discredited, so berated, for having gone into Mexico, subject to the laws of Mexico, just as those German capitalists and German operatives came to the States? If for thirty years the Mexican government has encouraged us to come to Mexico, and for the same thirty years our own American government has encouraged us to go to Mexico, does our own American government not owe us now a proper consideration? Does the particular feature or incident that Mr. Woodrow Wilson is now President absolve the American government from its moral and material obligations to us that have resulted from a thirty years' continuous policy of encouraging American commerce in Mexico?

It is an outright misrepresentation of facts to say that the exploitation of natural resources and of ordinary commerce in Mexico by foreigners is as a whole based on "concessions" or improper privileges that operate to bleed the country for the undue benefit of the foreigner. There may have been an occasional instance in the earlier years of Mexico's development, just as there may have been in the States, when undue profits were made. But 98 per cent of the "concessions" given in Mexico are as just and as conformable to the laws in vigor as can be found in the States. The crass ignorance, the petty pigheaded indifference of our home people and our home government to the correct meaning of the word "concession" as used in the Spanish language excites our derision. In the States a corporation secures a "charter" that gives legal permission to operate the expected business under the restrictions placed by law. A peanut vendor must also secure his legal permission, and it will be called a "permit" or "license." In Mexico these same permissions would be called "concessions" and would have honorable significations; but the American signification of the Spanish word "concession" infers something dishonorable. This idea has really become an obsession in the States.

We Americans derive much amusement from deriding the German "Kultur." Probably their "Kultur" is open to derision and censure. But the new American "Kultur" lately expounded by our home people and government—"that the flag does not follow an American when he goes to a foreign country"—is many times more despicable, more unworthy of a great nation. And we think it is really dangerous for the welfare of the nation.

All this is said in an endeavor to demonstrate that the American with material interests in Mexico is entitled to the good will, the moral support, the material support and the protection of his home government. Besides this, the American government has arrogated to itself the supervision of the affairs of all foreigners in Mexico, and will therefore have to render accounts some day to all foreign governments.

Our money is invested in Mexico; our business is not going on; our holdings are being injured because the existing authority in Mexico is persecuting our holdings with an apparent view of forcing us to abandon them completely and thereby suffer financial ruin. They do not clearly confiscate, but they do actually sequester our properties. Shall we quietly submit to conditions and let everything go by the board? Shall we try to meet every day's new, arbitrary decrees calling for more and more ready cash put in, so as to try to see the game through until the extortion be satisfied and we be permitted to carry on business under legitimate conditions?

It is hard to decide. Undoubtedly all institutions of limited financial resources will be hard hit, and many

of them will be ruined. The big, strong concerns will die harder.

Is there any hope that the Carrancista organization will be able to establish finally a stable government and bring peace to Mexico? None whatever. They are as able and competent to govern Mexico, and as deserving of the good will and support of good people, as the Industrial Workers of the World would be if given a chance at governing the United States.

Can Villa ever come back, and could we put any hopes in a government that he might establish? No. Villa lost the chances he had when he became his own true self and tried to assault the young French lady in Mexico City on his entrance there. The painful fact that he could never "be," any more than Huerta could "be," was forcibly brought home to President Wilson by the French Government's outright declaration. The next problem for President Wilson was that of finding a pretext for disowning Villa without letting the gentle public know the regrettable reason. So we have the statement that when later the famous call was made to all combatants to come to camp to settle their differences, the Villista chieftains answered: Agreed. The Carrancista chieftains answered: Agreed, but in the end we shall agree to whatever our First Chief shall decide. Wisdom of Solomon. Villistas are but individual parties bound together by but a gentleman's or bandits' agreement. Carrancistas have formal organization, discipline, and are therefore entitled to preference. Decision by the Court: Recognize Carranza with all the pomp and ceremony of war.

Was there any rhyme, reason or sense in any one's being recognized? It appeared to be thought that simple "recognition" was all that was needed to stabilize any government in Mexico. The American government seemed to think that its recognition would make or unmake any old government. We have seen that its recognition of Carranza has not made nor can "make" his government. We saw that its withholding or recognition of Huerta made much trouble for the old man, and possibly did "unmake" him; though we are inclined to believe that the thousand-and-one ways employed to hamstring Huerta were what really "unmade" him.

Can Feliz Diaz carry through a successful revolution and establish a stable government? Not with the limited backing that he appears to have. If he were a real strong man and of personal resource he might make quite a bid for it.

What about Zapata? Zapata is a bushwhacker, pure and simple; a four-flousher, and a very poor aid in military sense, as Villa found from experience. But it will call for the services of the Apache Indians to make a thorough job of finishing him.

Can Carranza retain control of the government and also physical possession of the country in face of the combined opposition of Villa, Zapata, and Feliz Diaz? He cannot, unless he can obtain the material as well as the moral backing of the United States; and material backing must mean loan of sufficient money.

Can Carranza obtain that material backing? It is unsafe to guess at what President Wilson may do in the matter; he has shifted, side-stepped, back and filled, and eternally hesitated on the Mexican question until no mortal man can guess at what he may do next. I think that we can hazard one guess at one feature, and that is that if in the course of human events it again comes up to him to recognize or not to recognize some man as President of Mexico, he will immediately and in a loud voice declare that he will never, no never, recognize any man as President of Mexico.

Assuming that President Wilson exercises no particular initiative on the subject, can Carranza get the necessary loan? Not until his government adjusts it-

self to civilized customs; and it is improbable that it can do that, because its adherents, in the main, are so radical and arbitrary, and so hard to control that it is unlikely that it would be permitted to carry through any healthy, moderate program that it might wish to.

What effect has the European War on the Mexican question? It is commonly conceded that since the war came on it has been sufficient reason for refraining from radical action toward Mexico. But it is like the Irish question—when the war ends, the question will bob up again.

During Huerta's tenure of power, which was for a year and a half preceding the opening of the Great War, with all great nations, excepting the United States, having recognized Huerta, with all foreigners in Mexico vigorously protesting to their home governments about the state of affairs—the stock answer that other nations sent back to their nationals in Mexico was, "that your home government regards it as your patriotic duty to submit gracefully to what is going on; do it to aid your own country's best interests. The American Government's policy toward Mexico is producing results that we never before dared hope for. Its loss of prestige, and the resentment aroused throughout all Latin America are exceedingly pleasing to us. Its loss is our gain."

And to think that that state of affairs has continued for two and a half years more, and the end is not yet in sight.

Assuming that the European War continues for four years more, and that President Wilson makes no change in his Mexican policy, what is likely to occur in Mexico?

Disintegration of the Carrancista government; short-lived attempts by other men to take Carranza's place; growing power of Villa and of Feliz Diaz; more bushwhacking by Zapata; total anarchy in economic affairs and industry in general; more and more losses by foreign interests. And when the limit of endurance has been reached, the foreign, material-interests people will for the first time enter into Mexican politics; will organize for particular interests of Villa, of Feliz Diaz, of the old-time, respected Porfirio Diaz people, with a considerable proportion of foreigners in active service, into a compact, well-equipped organization that will sweep Mexico and will establish a government so strong and so stable that our present American dream of dominating politics from the Equator to the Canadian line will never come true.

Y. X.

The Recovery of Molybdic Acid from Phosphorus Filtrates

To the Editor of Metallurgical & Chemical Engineering

SIR:—The following method has been used by the writer for the last two years and has proven quite a saving, considering the present price of the reagent.

The filtrates from the determination of phosphorus are saved in a suitable container, microcosmic salt is added, and from time to time as the solution increases in volume it is tested to see that sufficient phosphate is present to throw down all the molybdate. When considerable yellow phospho-molybdate precipitate has accumulated decant off as much of the clear liquid as possible, and then filter off the yellow precipitate using suction, and wash several times with dilute nitric acid and then several times with water. Suck the precipitate as dry as possible. Now take a small weighed portion of this precipitate and dry at 105 deg. C. to determine the amount of moisture in it. After the moisture is known weigh out enough of the moist phospho-molybdate so that it contains 115 grams of the dried precipitate. Place this precipitate in a liter flask or

beaker, add 100 c.c. of water and 100 c.c. of ammonium hydroxide and warm to about 80 deg. Stir the contents of the beaker thoroughly and if all the precipitate does not dissolve add ammonium hydroxide slowly with stirring until all has dissolved.

Cool this solution under the tap and add 150 c.c. of ammonium hydroxide and then a saturated solution containing 10 grams of magnesium nitrate. Shake vigorously several minutes and then allow the precipitate of ammonium magnesium phosphate to settle over night. Filter with suction, sucking the precipitate as dry as possible. Make this filtrate up to 750 c.c. with water, cool and add it to a cooled solution of 625 c.c. of water and 625 c.c. of nitric acid. The reagent is now ready to be used to precipitate phosphorus from solutions.

The precipitate of ammonium magnesium phosphate is dissolved off the plug with dilute nitric acid and the acidified solution is added to the container in which the waste filtrates are kept, and in this way less microcosmic salt is necessary for throwing out the molybdate for further recoveries.

E. W. HAGMAIER.

Buffalo, N. Y.

Valence and Valence

To the Editor of Metallurgical & Chemical Engineering

SIR:—After reading the article entitled "Inadequacy and Inconsistency of Some Common Chemical Terms," by Carl Hering, on page 649 of your journal (Vol. XV, Dec. 1, 1916), I looked the matter up in some of the current textbooks of general chemistry and was more than surprised at the meagerness and looseness of the treatment of the topic of valence there exhibited. The subject is discussed so thoroughly and the principle is used to such an extent in the chemical instruction given in the courses at the Michigan College of Mines, under the supervision of Dr. C. M. Carson, that I had not imagined that the matter of valence would be handled so lightly elsewhere.

This condition of affairs exists probably because the importance of the concept of valence is not widely appreciated. And in this connection it might be well to suggest that the majority of the teachers of chemistry would welcome more frequent expressions of the opinions of chemical and metallurgical engineers relative to the greater or lesser importance to be assigned to the various features in courses of instruction in chemistry. One effort along this line resulted in the editorial on "Fashion and Style in Chemistry," on page 501 of your issue of Nov. 1, 1916 (Vol. XV).

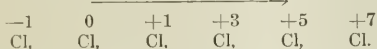
In the instruction given at this institution the word valency is used to denote the more or less variable capacity of an atom of an elementary substance to combine with an atom or atoms of other simple substances as exhibited in its known combinations. No qualifying signs or numerals are applied in connection to this general property word. But such signs and numerals are applied in connection with the term valence which is defined as the kind, in terms of polarity, and the amount of the chemical combining capacity of an atom of an elementary substance, as manifested in the given case, relative to the combining capacity of the atom of the standard substance, hydrogen, to the atom of which a positive valence of one is assigned.

Here the concept of valence is used to enable a student to write the formulas of all possible normal salts without the excessive use of the memory that would otherwise be necessary. Most equations are balanced by a modifications of the valence method of O. C. Johnson. And the relation expressed in the equation—chemical equivalent $\times$ valence = exact atomic weight—is made use of in the calculation of these quantities. In the

electrochemical work the correspondence between valence and the ionic charges is emphasized and applied. Exercises and problems involving these ideas are given in sufficient number and variety so that the concept of valence can become a really useful tool.

It is only in the case of persons with sharp impressions requiring modification that there is any difficulty about the introduction of a new word to replace a less comprehensive one. If the terms reduction and adduction are properly explained and illustrated in the first instruction that a student receives in chemical work, he will have no subsequent difficulty in keeping them in their proper places alongside the less general terms deoxidation and oxidation. The use of the following scheme, shown as applied to chlorine, has been found helpful in instruction of this kind:

Valence change in adduction reactions.



Valence change in reduction reactions.

F. B. WILSON.

Michigan College of Mines,
Houghton, Mich.

The Protection of Iron and Steel

To the Editor of *Metallurgical & Chemical Engineering*

SIR:—In a paper read last September before the American Electrochemical Society it was brought out that the coating metal must be electropositive to the metal to be protected. If the coating metal is electronegative, then the slightest break or pin hole in the coat will allow moisture to set up a galvanic couple; the iron or steel will then not only rust, but corrosion will go on at a greatly accelerated pace.

That is why tin, lead, brass, copper and nickel are all very poor protectors against the weather. These are all electronegative to iron or steel. The only available electropositive metal is zinc.

Unfortunately zinc is brittle and unless great care is exercised to not crack it, split, or foliate it, when working the coated articles, it leaves relatively large areas unprotected. It is not always feasible to redip or replat the articles after surfaces or seams have been damaged by bending, riveting, calking, etc.

Alloys of zinc with tin and lead are tough. Unfortunately it is difficult to put them down. In the hot bath the alloys have a tendency to segregation that is so serious as to demand great accuracy and care in securing and maintaining just the proper heat, not only in the bath, but also when the coated article is cooling; otherwise the brittleness of the zinc supervenes; when segregation has caused areas to be coated with the separated-out lead or tin, these areas are not zinc-coated and therefore as subject to rapid galvanic corrosion as though no zinc were used, but pure tin or lead.

A relatively new coating process is fortunately available. Zinc is reduced to a very fine powder, containing very little oxide or other impurity. This is mixed with a suitable flux to the consistency of a creamy paste that is applied cold with the brush, by dipping or spraying. The metal to be protected is, of course, first cleaned as it is for any method of protection. The article is then heated in any convenient way slightly above the melting point of the zinc. It is obvious that the means of putting on the cold Epicassit (the name given to the process) or the means for heating are relatively immaterial to the result, but governed chiefly by convenience, character and quantity of the article.

In order to secure a very tough and therefore ductile coating that will resist bending, twisting and hammering without cracking or splitting off, tin and lead are added

to the pulverized zinc. The segregation found in large baths is absent, as the coat is, of course, very thin as compared with a bath. Nor can there be segregation as the coat is melted down, because the particles of zinc, lead and tin powder are separate and not alloyed as a rule; these particles are so small that the protective electrogalvanic action of the zinc extends to the adjacent lead and tin particles as well as to the iron or steel underneath. Epicassit-galvanized articles have much more of the bright, smooth character of tin plate than is the case with pure zinc.

This method is equally useful whether employed initially for entire surfaces or whether used to repair damage in galvanized work, whether caused by time or in field assembly. The coat may be applied externally or internally, over whole surfaces or only to certain areas. The articles may be coated by being brush-painted with the cold epicassit, by spraying or by dipping. The application of heat has just as wide latitude; baking ovens, heated tumblers and the blast torch are used. Any of the softer metals that can be reduced to a fine powder are used as pure tin, pure lead, pure zinc and their mixtures in various proportions. While it is but little demanded, it is entirely feasible to apply dissimilar coatings on the inside and outside of vessels.

One of the chief uses of Epicassit is that referred to of providing a very tough and adherent coating of zinc of great latitude as to method and ease of application.

HENRY HESS.

Philadelphia, Pa.

A Chemist's Vacation

By Edward Hart

Visiting time had come. For forty years I had taught and given much of my time to others. Now vacation days had dawned. No longer must I face a round of lectures, quizzes and the daily drudgeries of the teacher's task. I packed my grip and started south.

In the days when Dr. Mallett and Dr. Prescott and Henry Carrington Bolton and William McMurtrie were still with us, we had come together every summer as Section C of the American Association for the Advancement of Science, and in the evenings with others as Section Q—not announced on any calendar of our meetings. In the daylight we told chemical stories and in the evening others. Now the select company had grown until it seemed like a mob. I missed the old faces and longed to see them once more.

I reached Washington in the evening and after dinner made my first call on Farmer Wiley. He was, as befits a farmer, in his shirt sleeves with an apron around his slim waist making sausage. Mrs. Wiley was assisting and I joined the party. We made 24 lb. of sausage, good sausage. I ate some of it next morning—and talked; how we talked!

Next morning, I looked up Frank W. Clarke and listened while he told me about the composition of the skeletons of those living in the sea and the geologic conclusions to be drawn. And I responded, dilating upon the green sand of New Jersey, how I had discovered that it consisted of about 60 per cent common quartz sand each grain covered with 40 per cent of green glauconite. Then he read me this poem written in his early days:

THE POLITICIAN'S PRAYER.

By F. W. CLARKE.

Our Father—whether in Heaven or Hell
We hardly know—
Look down (or up) to where we dwell,
And while our supplications swell,
Thy gifts bestow.

Give us the counting of the votes
Election day,
Let none of our men turn their coats,
But send the opposition boats
Salt River way.

Let slander, malice, fear and fraud
This autumn fall!
But if such tricks should be abroad,
Expose our enemies, O Lord,
Let ours prevail.

If base repeaters cheat the polls,
Their crimes betray!
Strike terror to their guilty souls!—
But write their names on Mercy's rolls
Who vote our way.

Give us by honest means success
In all this fight;
But if misled by bitter stress,
We save the realm through crookedness,
Lord, make it right!

We must, O Father, must succeed:
"This is Thy cause,
O! help us in our hour of need,
The pockets of the rich to bleed,
That we may vindicate our creed,
And make Thy laws.

But if the people should decide
Against our case,
Let naught of evil me betide,
Let me find favor with the other side
And get a place.

Then I visited Dr. C. E. Munroe, the great census expert, famed as well for his knowledge of explosives, and we lunched at the Cosmos Club, where I found Fearar of State College, Pa., and Bigelow of the National Cannery Association who was good enough next morning to show me what good work he had accomplished at his new task.

My good host had placed his auto and driver at my disposal and we drove to the Bureau of Standards where Dr. Hillebrand, famed for exact analytical work, showed me through his new laboratory.

From there I visited my friend Swavelly of the Army and Navy School, a graduate of Lafayette College and an active and influential alumnus. During the day I made a visit to the Bureau of Chemistry of the Department of Agriculture and saw my friend Patterson at the meeting of the official Agricultural Chemists in session at the Willard. This was rapid work for two days but I had far to go. That night I bade Washington adieu and started for Charlottesville, Va., seat of its famous university. Here I was met by Dunnington, a young man when we last met, now talking of retiring. We visited Dr. Mallett's laboratory together—still as he left it—and talked about his great work. Dunnington had nothing to say about his own work. It was all Mallett. What a beautiful legacy is a loving memory like this! Dunnington, too, is building a new laboratory. It was here that Edgar Allan Poe and Woodrow Wilson and Richard K. Meade were students. In the distance Monticello could be seen.

In the afternoon I left for Staunton, which Virginians pronounce Staanton, on my way to Lexington, the seat of Washington and Lee University. After the civil war Robert Edward Lee, the greatest general the war produced, became president of the university which Washington had founded. Here he died and lies buried in a beautiful mausoleum with his wife and other members of his family. His study has not been touched since his death. If I had been a student here I should have been very proud of my alma mater. I was welcomed by my old friend, James Lewis Howe, famous for his work on the platinum metals and for his annual reviews of the progress of chemistry. Next morning I talked to the chemical students and met the bright young members of the teaching force.

In the afternoon we visited the Virginia Military Institute and met the professors of chemistry. It was here that Stonewall Jackson taught when the war broke out. Here he enlisted the first company of his famous foot cavalry, and here he is buried. Lexington should be proud of her great dead. Lexington is very proud of the beautiful Doremus Gymnasium and of the way in which the money for it was given.

It seems that Mr. and Mrs. Doremus visited many

colleges and finally decided that Washington and Lee was the most deserving. These visits were unannounced and the gift of \$2,000,000 was entirely unexpected. "Just think," said one of the professors, "what a reception he would have had had we known."

From Lexington a business call sent me back to Richmond, which I had not visited for many years. In the lobby of the Jefferson a Confederate veteran was selling Confederate money and Indian arrow heads. Richmond is a fine city, and appears to be growing rapidly. The chief occupation of the authorities is to find some new way of levying taxes. Even the capital of the merchants is to be taxed. I saw Dr. Carpenter, grown old in the service of the Virginia Carolina Chemical Company, and Dr. Wightman, the bright and active young professor of chemistry at Richmond College, who takes the place of Dr. Bingham, now my colleague at Lafayette.

From Richmond I journeyed to Chapel Hill, N. C., to visit my old friend, Dr. F. P. Venable. When I first knew him, Dr. Venable, who is the son of a former professor of mathematics at the University of Virginia, was professor of chemistry at Chapel Hill; then the trustees made him president. For fifteen years he bore this heavy burden and built fourteen buildings; then he asked to be allowed to go back to his first love. To mark their appreciation of his services the trustees created the Francis P. Venable Professorship of Chemistry and made him the incumbent for life.

Now he has begun life anew, and with Dr. Bell, a graduate of Dr. Lash Miller of Toronto, has undertaken to redetermine the atomic weight of zirconium.

North Carolina is a sort of chemical slop jar. In variety of minerals she is not to be excelled on the face of the earth. Zircon is one of these, and the atomic weight of zirconium has never been satisfactorily determined. Venable took me to his laboratory and showed me how he made zirconium chloride, how he had one by one overcome the innumerable difficulties until he now felt sure of ultimate success. I rejoiced with him, and told him what I had been doing. In the evening Dr. Herty came over to see me. Herty is president of the American Chemical Society and is to edit the "Journal of Industrial and Engineering Chemistry." In my further journey through the Southland I heard much of the Herty turpentine cup. Turpentine is a great industry in the South and Herty has done good work there.

Next day was Sunday, and we went to hear a sermon by Mr. Moss in the Presbyterian Church. It was a unique sermon—I never heard one like it—full of real meat. In the wall back of the pulpit were four marble tablets. One of these read as follows:

In memory of
Elisha Mitchell, D.D.

Born in Connecticut 1793,

Died on Black Mountain, N. C., 1857.

Professor of Mathematics and of Chemistry U. N. C.
1817-1857.

Ordained minister by Orange-Presbytery 1821.

Stated supply of this church for many years.

One of the builders of this house 1849.

After service we strolled around the town and admired the fine old houses set back from the streets and the beautiful gardens. The atmosphere reminded me of Oxford—there was the air of friendliness and genial ease though not quite so straight-laced as the Oxford I last saw.

Some time since, talking with the successful young sculptor Harry Raul, I said to him, "Why must we forever continue to reproduce in our architecture the Greek acanthus leaf, the egg and dart and the walls of Troy? Why not have an architecture of our own

in which the Indian corn, the wheat, the strawberry, mullein, cotton plant, the cypress and the poplar play a part?" Here I found the answer to my query in the law building, in which this idea had been carried out with happy effect. It is worthy of further elaboration. Why not have an architecture of our own and discard our slavish following of Greek and Goth?

In the absence of her mother, Miss Frances Venable presided over the dinner, and Drs. Wheeler and Bell were also guests. We spent the afternoon telling stories. F. P. is a famous raconteur. His darky stories are especially good. Dr. Wilson, librarian, who dropped in during the evening, reminded us of the darky who said apollinaris tasted like your foot's asleep.

Next morning I rode my auto to Durham and then by train to Winston-Salem, where I found two of my old students, J. L. Ludlow, a prosperous civil engineer, and Robert A. Rice, business manager of Salem College. Ludlow is buying spent pyrites from the sulphuric acid companies. It contains 2 per cent sulphur. He roasts it to a content of 0.05 per cent and at the same time clinkers it and sells the clinker to the iron blast furnaces. My two hours' stop here was soon at an end, and I went back to Greensboro on the way to Atlanta, my next stop. On the way to Greensboro we passed a station called Terra Cotta, where large stacks of the finished product show that the station was properly named. I found everywhere through the South evidences like this of an industrial awakening. Those who think the South still sleeps have not been abroad.

My visit to the Georgia School of Technology at Atlanta was a very pleasant one. I was very kindly treated, and although my visit was brief and made in a pouring rain it was very enjoyable. That evening I dined with Professor Daniel, who has done good work on the hydrogenation of oils; after dinner we went to the movies and talked shop instead of watching the pictures.

I reached New Orleans at 11 p. m. and went to the Grunewald, where, to my great surprise, I found my old friend Dr. A. L. Metz, chief of the chemical force of Tulane University, waiting to receive and welcome me.

Next day was Thanksgiving. In the morning I called up my old student G. G. Earl, chief engineer of the New Orleans Water Sewage and Drainage Commission. Mr. Earl drove me to one of the six pumping stations for lifting the sewage and drainage into Lake Pontchartrain. We saw two of the monster pumps designed and built under his direction capable of lifting 36,000 cu. ft. per minute. It certainly was a great pleasure to see what good work our graduate is doing.

At noon, with the chemical faculty of Tulane, I was Dr. Metz's guest at the Louisiana restaurant, after which we adjourned to his home, where we spent the afternoon and evening.

Next day, at Professor Williamson's invitation, I talked to the students in chemical engineering and aired my peculiar views on teaching. During that and the following days I visited the sugar plantation of Edward Godchaux at Reside, La., where I saw cane sugar made at the rate of 2000 tons daily, to the plant of the International Distilling Company at New Orleans, where cologne spirits and gin are made from black strap molasses, and two experimental plants, where potash is being recovered from the slop.

On my way home I stopped at Auburn, Ala., to see Dr. B. B. Ross, and we spent part of Sunday in a visit to Tuskegee, where John Washington kindly showed us over the interesting experiment. Another stop was made at Copperhill, Tenn., to see a new nitric acid

plant with twenty-one Hart condensers just installed with all the modern improvements. It was very interesting to see how my modest experiment of 1891 had expanded in the course of time into a large industry.

Easton, Pa.

Coming Meetings and Events

American Institute of Chemical Engineers, New York, Jan. 10-13, 1917. (See p. 55.)

Society of Chemical Industry, New York Section, Perkin Medal Award, New York, Jan. 19, 1917.

Joint meeting of New York Section of American Electrochemical Society, American Chemical Society and Society of Chemical Industry, Rumford Hall, Chemists' Club, New York, Feb. 9, 1917.

American Institute of Mining Engineers, annual meeting, New York, Feb. 19-22, 1917.

Western Metallurgical Field

Ferro-Alloys

A 200-kw. electric furnace is being installed at Utah Junction, near Denver, for the production primarily of ferro-tungsten. The new company will operate under the name of the Ferro-Alloy Co. The contract for the plant has been let and it is hoped that operations will begin in 90 days. If the production and sale of the ferro-tungsten justifies it, other ferro-alloys will be manufactured. These are ferro-molybdenum, ferro-vanadium, ferro-manganese, ferro-uranium and ferro-silicon.

Case of the Government Against Trona Co.

The case of the government against the California Trona Company which has been trying to extract potash from Searles Lake was called on Nov. 27, and was continued pending a final agreement on stipulation so that the case will probably come up in a short time again. The government, in order to avoid a long drawn out legal battle, is endeavoring to put the case up to the Department of the Interior on the basis of a stipulation of facts.

The Trona Corporation has applied for patents in this case covering four 28-acre locations, furnishing a test case. An examination was made and charges preferred against the application, alleging:

First, the form and character of the deposit was not such as to be subject to location under placer mining laws.

Second, the application of the California Trona Company was not made for its own use and benefit, but for the use and benefit of a foreign corporation, thus making the application subject to disqualification.

The endeavor now in getting a stipulation of facts is to get a statement as to who owns the stock of the California Trona Corporation. It is known to be controlled by English interests. The procedure at present is to get statements on both sides and come to an agreement to prevent a legal battle.

The Trona Company has about completed a large plant at San Pedro (Los Angeles) and the machinery evaporators, centrifugals, etc., have been installed. The Searles Lake plant at Trona has been modified to a great extent, and much of the apparatus is believed to have been scrapped. As far as is known no production of potash has been made as yet by the Trona Company.

The following facts as to the plants at Trona and San Pedro are given in the *Mining and Oil Bulletin* for December of the Los Angeles Chamber of Mines and Oil.

The company's plant at Trona, Searles Lake, San Bernardino County, comprises a battery of 2000 hp. Bab-

cock & Wilcox boilers, housed in a steel and reinforced concrete building with a vertical flue of steel and concrete which is a monument to the designing and constructing engineers. This chimney is 150 ft. in height, and 9 ft. in diameter in the clear at the top. The evaporating building is 109 ft. high, 200 ft. long and 70 ft. wide, also constructed of steel and concrete. In addition a building 600 by 90 ft. houses the machinery for the production of potash salts and borax. The plant also includes a reinforced concrete spray pond for cooling the water used for the condensation of vapors; a 10,000 barrel oil tank; two 500,000 gal. steel tanks for brine, and several other tanks of 10,000 gal. each. The offices and laboratory are in a two-story reinforced concrete building. F. O. Engstrum Company, with offices at Fifth and Seaton Streets, Los Angeles, secured the contracts for the general construction work; all tanks used were furnished by the Llewellyn Iron Works, of Los Angeles and Torrance; steel and machinery were purchased from eastern dealers.

The camp equipment is modern in every detail, and comfortable bungalows are provided for the employees. A 32-mile standard gauge railroad has been completed, operating between Searles, a station on the Southern Pacific, and the company's plant at Trona. The brine is treated at Trona by evaporation and the concentrated product is to be shipped to the refinery at San Pedro.

When completed, the refinery at San Pedro which is not far from Point Fermin, will have a capacity of 200 tons of potash per day, and the output will also include a daily production of sixty or more tons of borax. Later the company will put on the market sodium carbonate, sulphate and chloride, and intends to erect additions to the plant for the manufacture of such potassium or sodium salts as the market may require.

The power plant at San Pedro contains 1000 hp. Babcock & Wilcox boilers, housed in a steel and reinforced concrete building, with a chimney of the same dimensions as that at Trona. The principal factory building is 86 ft. high, 200 ft. long and 80 ft. wide. The office building houses a modern laboratory, drafting and engineering departments. A warehouse 100 by 300 ft. will soon be constructed, also other necessary buildings with machinery for the preparation and sacking of the company's products. It is expected that the refinery will be operating before Jan. 1, 1917. The plant at Trona is, of course, now in operation. Plans are now being made to increase the size and output of both plants.

Company Reports

The Annual Report of the Vindicator Consolidated Gold Mining Co. for the year 1915 gives as one of the main features for this year the buying of the Golden Cycle Mining Company's property by the Vindicator Company. The latter adjoins the property of the Vindicator and consists of 43.5 acres. This purchase raises the total acreage of the Vindicator from 86 to 130 acres. The various departments of the two properties were consolidated.

In October, 1914, the Vindicator concentrating mill was put into operation, but did not run at full capacity until the first part of 1915. This mill was designed to handle the reject from the ore house and produce a shipping product from material which otherwise would have gone to waste. During the year the mill has handled an average daily tonnage of 250 tons in one shift of eight hours. The average ratio of concentration was 11 to 1. The average percentage of recovery was 55 per cent on an ore running \$2 per ton. The milling costs were only \$0.20 per ton. A complete return for the value expended was shown after only twelve months' operation.

Much experimenting has been done on the low-grade ore on the dumps averaging \$2 per ton or better, and on the low-grade ore in the mines and in the filled stopes. The engineers of the company, after thorough investigation, have recommended the remodeling of the shut-down mill at the Golden Cycle shaft. The flotation process will be used, and the mill is supposed to handle the rejects from the Golden Cycle ore-house and at the same time serve as an experimental station for the ores from all shafts. The capacity of the mill will be 300 tons daily and the cost of changing will be low. A 90 per cent recovery from material running \$1 per ton is expected. If this mill works out satisfactorily, after testing all the ores of the property, a modern flotation mill will be erected of not less than a thousand tons daily capacity. Such a mill will cost in the neighborhood of \$200,000, where a cyaniding mill of the same capacity would involve an expenditure of \$750,000.

During the twelve months' operation of the Vindicator and the ten months during which the Golden Cycle has been producing, there have been mined 218,487 tons of crude ore, which produced 125,397 tons of shipping ore averaging \$23.73 per ton. The gross value of the company's shipments amounted to \$2,164,668.92 and after deducting treatment charges and freight gave net receipts of \$1,718,022.21. Lessees over the same period of time shipped 49,188 tons of ore averaging \$16.57 per ton in gold. The gross value of this ore was \$815,182.59 and the net receipts amounted to \$546,363.55. The royalties received by the company from the lessees amounted to \$251,624.09.

The recovery of gross contents was 94 per cent of gold and 90.9 per cent of silver, a decrease of 1 per cent gold and 0.3 per cent silver. The value recovery based on net smelter returns shows 90.3 per cent against 89 per cent for the previous year, or a gain of 1.3 per cent. This is the highest net recovery in the history of the mill. The comparison of these last figures, coupled with the cost of operation, shows the efficiency of the mill. Had the supplies been normal in value an additional reduction of 35 cents per ton could have been made. The increased cost of chemicals is shown in the table.

The total cost to mine and mill the ore and market the products was \$7.78 per ton. The metal losses in milling and refining was equal to \$1.11 per ton. The profit per ton was \$4.77. The average gross value of the ore milled was \$13.66.

The Chicago Section of the American Institute of Mining Engineers held a dinner meeting at the Chicago Engineers' Club on Friday, Dec. 22. Mr. Alonzo G. Kenyon of the Powdered Coal Engineering and Equipment Co. spoke on "Burning Powdered Coal," and Prof. Harry B. Pulsifer of the Armour Institute of Technology spoke on "Metallurgical Plants About Chicago."

326th Meeting of the Colorado Scientific Society.—This meeting was held on Dec. 2 at the Colorado State Museum. Two papers were presented by Richard C. Hills, the first being "Some Rare Mineral Occurrences" and the second was entitled, "A Denver Made Spintharoscope for Counting the Helium Atoms Given Off by Radio-active Preparations."

The Perkin Medal for 1917 will be formally presented to Dr. E. Twitchell at the joint meeting of the New York Sections of the Society of Chemical Industry, American Chemical Society and American Electrochemical Society in the Chemists' Building, New York, on the evening of Jan. 19, 1917.

The Future of the Iron Blast Furnace

By J. E. Johnson, Jr.

That iron is the very basis of our industrial civilization will be admitted by the thoughtful, and many of our greatest supplies of iron ore are being rapidly depleted because of the increased per capita consumption of iron the world over, an increase which is destined to be greater in the future when the races in Asia and Africa increase their consumption of iron. Therefore, the question of a supply for future generations is one vital to the race and is worthy of some consideration here, in view of the fact that the changes in conditions which must come about will affect the economics, and through them the technology of the blast furnace. These conditions of increasing consumption and decreasing reserves have often in the past, particularly about the beginning of this century, been used to create a scare, on the ground that our supplies of usable ore were being so rapidly depleted that their exhaustion would occur within two or three generations. This is a point of view which seems to me preposterous, even leaving out of account the fact that the estimates of the world's iron ore resources, which were used in reaching this conclusion, were subsequently shown to be entirely inadequate. But the corrections which have since been made push into the future, only by a few brief centuries at most, the time at which the exhaustion of these reserves may be expected. It is then not here that our fundamental ground for optimism must be found, but in the fact that as we lower the percentage of iron in the rock, which we agree to call "ore," the quantity of such ore increases at a rate out of all proportion to the decrease in iron content.

In considering the decline in iron content, especially as to the rich ores, we must remember that as there are two oxides of iron containing in the chemically pure conditions different quantities of iron, we must consider them separately. Magnetite Fe_3O_4 contains 72.4 per cent of iron, hematite Fe_2O_3 , 70 per cent.

There have been magnetites found containing over 70 per cent in iron. In one region, a deposit was found, historically famous for its size and purity combined, in which there were more than 60,000 tons of ore running 70 per cent and over, but this same district contained millions of tons of ore 60 per cent and better, tens of millions of ore of 50 per cent and better, and hundreds of millions of tons containing 30 per cent and better. This, being magnetic ore and free milling, is considered as commercially available ore to-day, and while the same thing is not true commercially of hematites, yet to assume that methods will not be found to concentrate these also is to insult the intelligence of posterity. If we were to drop down to rocks containing 20 per cent of iron, the increase would be still greater.

I believe that this whole matter could be handled accurately upon the basis of the probability curve, but I am not mathematician enough to do it, nor have I been able to obtain the assistance of a mathematician who could, but such tentative figures as I have, obtained from an authoritative source, indicate that for every million tons of iron ore from 60 to 65 per cent iron content there are 85,000,000 tons of 30 to 35 per cent, and the increase is even more rapid as we drop below this point.

It is obvious then that we shall never run out of iron-bearing material—we shall simply use leaner and leaner material as time goes on.

This process has already proceeded further than we realize, unless we stop to look up the records of the past. A good standard of comparison is the fact that

when my father made an examination of the famous Chapin mine in 1891, just a quarter of a century ago, he found them throwing 56 per cent material over the dump as "rock."

The direct result of further change in the same direction will be to increase the cost of pig iron for the reasons elaborated in earlier articles, and this fact must be frankly faced. But we have seen increases in price of pig iron many times greater than that which would result from reducing the iron in the ore from 55 to 30 per cent, but neither the consumption of iron nor civilization was checked by these conditions; if one took only the superficial view they would appear to have been accelerated, and it is, therefore, reasonable to assume that if this condition of high prices becomes chronic for industrial reasons, instead of being spasmodic for commercial reasons, civilization would scarcely feel the difference, especially as it is a change which will take place with exceeding deliberation.

A change, such as that indicated above, would increase our resources in ore to an extent which staggers the imagination, and there is no reason to doubt that the tendency to increased cost, due to the use of leaner ores, would be met by technical and industrial improvements which would minimize if they did not wipe out the increase.

The same thing has happened in other industries. Gold ore worth \$10 per ton was probably not commercial fifty years ago; to-day gold is being extracted at a profit from ores which contain values of only \$1 per ton. Similarly the copper ores of fifty years ago were rich. In the early days of Calumet & Hecla the ore ran 3 per cent in copper and sometimes 4 per cent. It was sweetened by huge masses of native copper of such great size that in those early days of little or no equipment great difficulties were encountered in cutting them small enough to be brought out of the mine. Copper in that day commanded a price of 20 to 30 cents a pound; to-day mines are extracting copper from ore containing $1\frac{1}{2}$ per cent and less of the metal, and they could sell it, if they wished, at 8 cents a pound.

If nature has been more generous to the iron industry and endowed it with extensive supplies of ore, capable of immediate use in the furnace without beneficiation, that is no sign that the iron industry and civilization with it will be extinguished by the exhaustion of these deposits, and the consequent necessity of descending to ores containing only a fraction as much metal.

Advances are to be expected along both industrial and technical lines. Much of the value of the high-grade ores of to-day is made up of two elements—a rarity value, namely, the royalty paid to the owner because of the exclusive ownership of existing deposits, and a transportation value due to the necessity of bringing these relatively rare rich ores to the point of consumption.

If the day ever comes when we drop down, for instance, to 30 per cent ores, the bodies of these are so vast that exclusive ownership will be almost impossible, and the royalty value will greatly decline or fade away, while, owing also to the relative numerousness of such bodies of material, the chances are that they will be found much closer to the points of consumption than the rich but rare bodies of to-day. This, then, will tend to reduce the transportation values of these ores, or at least will tend to offset the increased cost of transportation, due to the greater number of tons required per ton of iron.

On the technical side, improvements may reasonably be expected along four lines—mining, ore dressing, by-products, and the furnace itself.

Mining

Cheaper mining is to be expected because we shall be able to choose among the most favorably located of the great deposits of low-grade material, and for centuries probably nothing but open pit work will be done upon them, which will mean a minimum of cost.

Ore Dressing

In regard to ore dressing, the metallurgy of iron is far behind any other, partly because of nature's hitherto bountiful supply of ores directly available, and partly because the blast furnace, being a willing horse, has often been made to carry an unfair burden. Its proper task is the reduction of iron to the metallic state from its oxide; it has also often been made to serve as an ore dressing apparatus and separate the iron from the gangue as well, for the good commercial reason that it furnished the cheapest way to do it, if other conditions were right. Most of the science of ore dressing for the iron industry, therefore, lies in the future, and there, as far as this work is concerned, we must leave it, since it is impossible to foretell the lines of development which will follow, and they would be out of place here, if we knew them.

By-Products

It is only within the last ten or twelve years that we have been accustomed to consider the by-products from the furnace as having any value, but leaving aside for the present the question of the gas, we are coming to an increased realization of the importance of the slag in making cement. As concrete construction grows in relative importance to steel, as well as in an absolute importance, and as the quantity of slag per ton of iron increases, which it necessarily must from the use of leaner ores, we must look for a wider and wider application of this slag to the production of cement. We may even hope that the present method of manufacture, which theoretically at least seems very crude, will in time to come be improved, revolutionized perhaps, so that what one furnaceman has been accused of dreaming—tapping iron out of the iron notch and cement out of the cinder notch of the blast furnace—may almost come to pass.

If the cinder can be converted into cement with a profit which will only pay for handling the gangue of the ore and the limestone to flux it, the furnace of the future will obviously be relieved of a heavy part of its increased burden.

The Blast Furnace

Turning now to the furnace itself, whatever we say or suggest must be taken in the light of prophecy and subject to all the errors and discounts to which all prophecy is subject, because if there were means whereby we could increase the economy of the furnace when running on lean ores beyond the present possibilities, obviously it would not be a matter for the future, but would be in process of being done to-day.

Turning back to the article on commercial considerations, it is easy to believe that the furnace of the future will feel no particular pressure on account of fuel consumption until the latter has risen beyond the point at which the furnace gases will supply all the heat and power requirements of the associated steel mill, except, of course, at isolated merchant furnaces having no such market for their power. The question as to how we shall reduce the fuel consumption, when this point is reached, is the ultimate question which the industry must answer, and though it is a long way in the future for us, there are visible, even to-day, means whereby it may be done. Of course, the possibilities of hotter

blast and all the other lines along which present developments are progressing will have been pretty well exhausted by that time; we must look for a more radical solution.

This, in my judgment, is to be found in the modern industry of separating the oxygen from the nitrogen of the atmosphere by purely physical means, and using this instead of air to blow the furnaces of the future. This idea is not novel in the industry. Experiments were made in the direction of enriching the oxygen content of the blast in Belgium a year or two previous to the breaking out of the Great War, but no important results were obtained, or at least those published were unimportant because the degree of enrichment was too small to produce any marked change. Some American furnacemen have taken the ground that no gain was to be expected on theoretical or practical grounds. If that contention be correct, the fundamental principles of the blast furnace, as set forth in a former article of this serial are wrong, the explanations of known phenomena made on the basis of these principles are incorrect, and there is scarcely an article in the serial which can be accepted without the most drastic revision. If, on the other hand, the thermal principles set forth are correct, then we may proceed to show quantitatively the effect which oxygen in different proportions would have upon the thermal relations in the hearth and bosh of the furnace.

Fig. 1 is a diagram giving the quantities of hearth heat obtainable per pound of coke (counting 0.85 lb. of fixed carbon burned in the hearth) with dry air blast at 1000 deg. Fahr., and with a mixture of equal weights of oxygen and nitrogen at atmospheric temperature. This diagram shows that at low critical temperature there is but little advantage in the oxygen blast, but as the critical temperature rises the advantage increases from a few per cent to several hundred per cent.

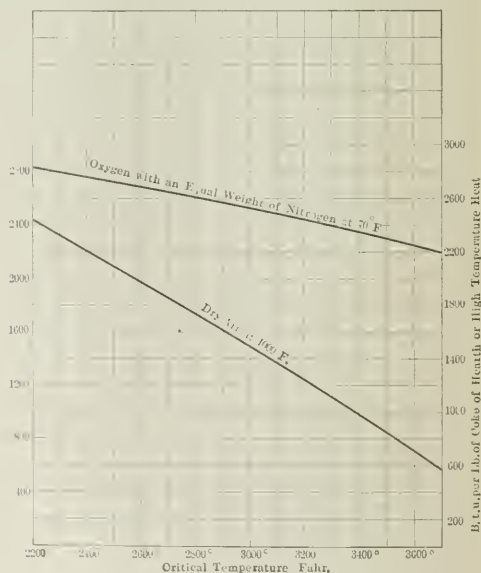


FIG. 1.—HEARTH HEAT PER POUND OF COKE (COUNTING 85 PER CENT FIXED CARBON BURNED IN HEARTH) AT DIFFERENT CRITICAL TEMPERATURES WITH BLAST OF DRY AIR AT 1000 DEG. FAHR., AND WITH BLAST OF EQUAL WEIGHTS OF OXYGEN AND NITROGEN

The study of this diagram enables us to see what changes may be made in the thermal operation of the furnace by the use of oxygen blast.

There are many who will doubt the possibility of obtaining the supply of oxygen which would be required for such a use, but the process of separating air into its component oxygen and nitrogen on an industrial scale by distillation from liquid air is now in actual operation at Niagara Falls, separating many thousand cubic feet of air per hour.

Those who remember the ridiculous claims made for liquid air some eighteen years ago, and their subsequent utter collapse, are inclined to deny the commercial possibility of that operation, on theoretical grounds, but this is not correct. The theoretical power for effecting the separation, figured on the basis outlined by Ostwald, the great apostle of physical chemistry, amounts to only 1 hp. per 6 cu. ft. of oxygen produced per minute. A modern 500-ton blast furnace requires 45,000 cu. ft. of air or 9000 cu. ft. of oxygen per minute, which would require, on the theoretical basis, 1500 hp. for its production, as against the 2500 hp. now necessary to blow the furnace.

The best performance of any actual air separating operation to-day requires about seven times the theoretical amount of power, so we are still far from being able to replace existing methods on the power basis. Processes are under development, however, which promise to reduce this power requirement by one-half or two-thirds; in other words, we hope to produce oxygen at an efficiency of 50 per cent, based on theoretical power, and there is no fundamental reason why we should not do so. Even this, it will be said, is no improvement over present conditions, and on the power basis alone that would be true. But this question cannot be decided on the power basis alone, for two reasons:

1. The heat consumption of the blast under present blast furnace conditions is not limited to power alone.

2. The result in the furnace itself must be considered.

In regard to the first point, it must be remembered that blast must not only be compressed, but it must be heated, and this operation requires about four times the heat required to supply power for compression; then there is the heating equipment, which costs as much as the power plant, all of which would be saved by the use of oxygen. This brings us to the second point, the effect of oxygen in the furnace itself.

It will be seen that for the average condition, 2750 deg. critical temperature, the hearth heat with the ordinary hot blast is about 1800 B.t.u. per pound of coke, while with the 50 per cent oxygen blast, it is 2625 B.t.u.; in other words, we can raise the amount of hearth heat obtainable from a given amount of coke nearly 50 per cent by the use of a blast containing one-half oxygen. If the critical temperature be higher the advantage is still greater.

Let us remember that it has been shown in the article on thermal principles that the rapid increase in fuel consumption with leaner ores comes principally from the increased slag to be melted, and the volume of slag increases with enormous rapidity as the percentage of iron in the ore declines. The average Lake Superior ore of 52 per cent iron produces about half a ton of slag per ton of iron. Ore of 33 per cent iron and 38 per cent silica produces about $2\frac{1}{4}$ tons of slag, which at 0.4 of a ton of coke per ton of slag means an increase of 0.7 of a ton of coke. On the same basis, an ore containing about 25 per cent iron Fe, 43 per cent SiO_2 , and 15 per cent Al_2O_3 , would produce 5 tons of slag per ton of iron which, on the basis of 0.4 of a ton of coke, would demand an increase of almost 2 tons in the coke required to make a ton of iron, working under present conditions.

If the total coke per ton of iron became 3 tons with ordinary hot blast, on the basis of the hearth heat developed, it would drop back to 2 tons with half oxygen blast.

But we must consider the development of shaft heat as well as hearth heat. With lean ore and half oxygen blast, we should require more than under present conditions, for two reasons:

1. The larger quantity of slag forming materials to be heated to the critical temperature in the shaft.

2. The smaller quantity of nitrogen present to carry heat from the hearth up into the shaft.

But we have seen in discussing thermal principles that a reduction of the amount of fuel required to smelt a given weight of iron automatically increases the amount of heat available in the shaft, because a larger proportion of the CO present at the top of the bosh is oxidized to CO_2 by the oxygen of the ore, with a correspondingly greater development of shaft heat.

We have seen further that solution loss is one of the prime causes of insufficient shaft heat development, as well as of insufficient hearth heat development.

In order to eliminate this loss more or less completely, especially in the upper regions of the furnace, where the concentration of CO_2 and the solvent action are the greatest, I have suggested a furnace in which the fuel should be fed down through the center of the furnace, and for some distance down kept from contact with the ore, while the gas was made to travel the last portion of its journey through the ore alone, thereby eliminating its alternating contact with ore and fuel, the prime cause of solution loss with the present process.

This design is shown by Figs. 2 and 3. The water-cooled steel mantle with a fluted bottom is supported from the top of the furnace, its top is sealed and no escape of gas permitted therefrom. The fluting is intended to promote a quick and intimate mixture of the ore and fuel in the lower regions of the furnace.

It is hardly necessary to say that this scheme has never been tried, nor has the use of oxygen blast in any percentage calculated to produce revolutionary results. The whole idea must, therefore, be counted as a dream, for the present, but in considering the possibilities of the future, as we now are, it is well to remember that incredulity has discounted the wisdom of the race many times oftener than credulity, and allowing that the supply of oxygen can be obtained, which is a possibility now almost appearing within sight over the horizon, there is nothing in the principles of furnace operation, as we know them, to cast doubt upon the possibilities of such a design.

Objections will naturally occur to the thoughtful, but they are more apparent than real. Perhaps the first would be the difficulty of maintaining the furnace structure in the intense heat produced by the combustion of carbon in oxygen, but the answer to this is easy. We do not desire or intend to produce any higher temperature than we now have. We propose merely to generate more high temperature heat, and then give it enough more work to do to bring the temperature back to where it is to-day, always remembering that, in the broad sense, the temperature prevailing in any zone of combustion is proportional to the amount of heat developed, divided by the thermal capacity of the materials present.

Another objection will be that the reduced area available for the passage of the gas will not permit the furnace to be blown at any speed worthy of consideration. Here, again, appearances are in error, because a blast containing one-half oxygen has a total volume less than one-half that of air containing the same quantity of oxygen. If by the use of oxygen we reduce the fuel

consumption to two-thirds, the gas per ton of ore becomes approximately one-half what it would be with atmospheric blast under the same conditions, and this can, therefore, pass out through an area one-third as large.

On the other hand, such a process has some advantage over the existing furnace in other respects besides fuel consumption. First is the production as a by-

Of course, we do not know that the blast furnace, the oldest industrial apparatus still in the service of man, will survive the changes which the future is to bring. Other methods of smelting iron have been proposed, and while they have in the main failed, a careful study of the thermal principles will show that they need not necessarily fail on theoretical grounds; but if the blast furnace remains our best, or even our only servant for the conversion of nature's stores of iron to our use, it is evident that there are long strides in sight which it may take, and that when these are taken it will be

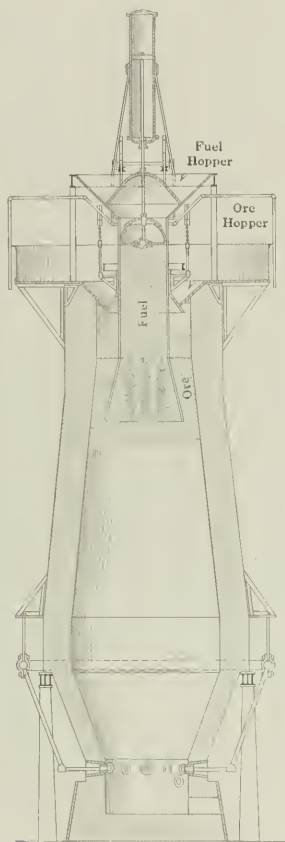


FIG. 2—PROPOSED DESIGN OF BLAST FURNACE FOR OXYGEN BLAST

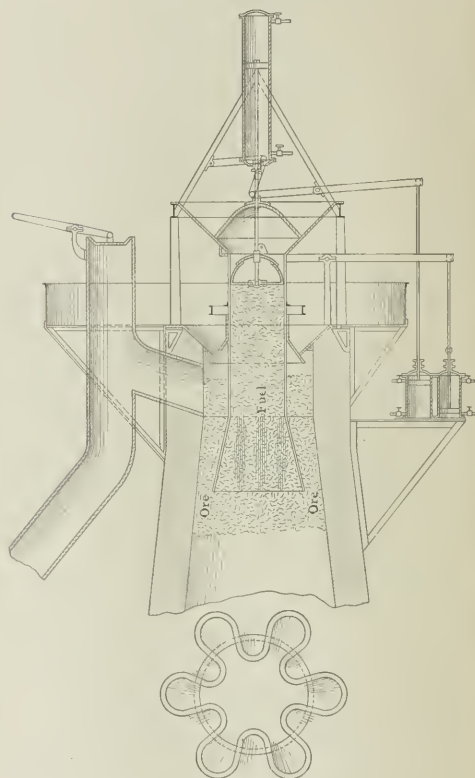


FIG. 3—DETAILS OF FIG. 2

product of a large quantity of pure nitrogen, and it is reasonable to believe that this would, to a large extent, come into use for fixation purposes. Second, because the fuel does not require to be penetrated by the gas column, but should be made as impervious as possible to it; a part of the fuel could be charged as coal, not coke, and this would save a corresponding proportion of the coking cost, and the investment for ovens.

There are other advantages over the present process if we could make this dream true. Not the least, perhaps, would be the elimination of the stoves and the consumption of gas required to heat them. The furnace would not need to have so large a volume on account of the much smaller volume of gas passing through it and the correspondingly greater concentration of the latter in active components. The furnace gas would be richer on account of the elimination of the nitrogen, in spite of being more diluted with CO_2 .

possible for us to use commercially as ores what we should now dismiss as rock, and that the supply of raw material thereby placed at our disposal is so enormously enhanced that we can more easily foresee the failure of civilization from other causes than from the failure of its supply of iron and steel.

Fuel Oil Requirements of the Navy.—In his annual report to Congress, Secretary of the Navy, Daniels, points out that when the three-year program already authorized by Congress is completed the Navy will require 6,721,000 barrels of fuel oil annually during peace. All new ships are oil burners and the navy has taken steps to acquire oil lands to be held in reserve. This future supply is threatened by legislation which would benefit others and the Secretary makes a plea for the upholding of public interest against private ownership.

Supreme Court Decision in Hyde Flotation Suit

The complete text of the decision of the Supreme Court, written by Judge Clarke, in the suit of Minerals Separation Ltd. and Minerals Separation American Syndicate, Ltd. versus James M. Hyde is as follows:

In this suit the complainants, the first named as the owner and the other as general licensee, claim an infringement of the United States letters patent No. 835,120, issued on the 6th day of November, 1906, to Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard, and John Ballot. The usual injunction, accounting and damages are prayed for. The District Court sustained the patent as to claims numbered 1, 2, 3, 5, 6, 7, 9, 10, 11, and 12; found that the defendant had infringed each of these claims, and granted the prayer of the petition. The Circuit Court of Appeals for the Ninth Circuit reversed the decree of the District Court and remanded the case with instructions to dismiss the bill. The case is here on writ of certiorari to review that decision.

As stated in the specification, the claimed discovery of the patent in the suit relates "to improvements in the process for the concentration of ores, the object being to separate metalliferous matter from gangue by means of oils, fatty acids, or other substances which have a preferential affinity for such metalliferous matter over gangue."

The answer denies all of the allegations of the bill and avers that in twenty-five designated United States and five British patents the process described in suit was "fully and clearly described and claimed," and it also avers that the claimed discovery was invented, known and used by many persons long prior to the time when the application was made for the patent in suit. Notwithstanding this elaboration of denial counsel for the defendant in the summarized conclusion to their brief rely upon only five of the many patents referred to as showing that the patent in suit was anticipated and is therefore invalid for want of novelty and invention, viz.: Everson (1886), Froment (Italy, 1902; Great Britain, 1903), Glagner (1903), Schwartz (applied for April 19, 1905, issued Dec. 19, 1905), and Kirby (applied for Oct. 17, 1903, issued Dec. 18, 1906). And the defendant, a man obviously experienced in the subject, says that, in his opinion, the whole basis of flotation concentration was disclosed in the Everson United States patent No. 348,157 and in the Froment British patent.

It is clear that in the prior art, as it is developed in this record, it was well known that oil and oily substances had a selective affinity or attraction for, and would unite mechanically with, the minute particles of metal and metallic compounds found in crushed or powdered ores, but would not so unite with the quartz, or rocky non-metallic material, called "gangue." Haynes' British patent (1860), and United States patents, Everson (1885), Bobson (1897) and Elmore (1901). It was also well known that this selective property of oils and oily substances was increased when applied to some ores by the addition of a small amount of acid to the ore and water used in process of concentration. United States patents Everson (1885), Elmore (1901) and Cattermole (1904).

Prior to the date of the patent in suit a number of patents had been granted in this and other countries for processes aiming to make practical use of this property of oil and of oil mixed with acid in the treatment of ores, all of which, speaking broadly, consisted in mixing finely crushed or powdered ore with water and oil, sometimes with acid added, and then in variously treating the mass—"the pulp"—thus formed so as to separate the oil, when it becomes impregnated or loaded with the metal and metal-bearing particles, from the valueless gangue. From the resulting concentrate the metals were recovered in various ways.

The processes of this general character described in the prior patents may be roughly divided into two classes. The process in the patents of the first class is called in the record the "Surface Flotation Process" and it depends for its usefulness on the oil used being sufficient to collect and hold in mechanical suspension of the small particles of metal and metalliferous compounds and by its buoyancy to carry them to the surface of the mixture of ore, water and oil, thus making it possible, by methods familiar to persons skilled in the art, to float off the concentrate thus obtained into any desired receptacle. The waste material, or gangue, not being affected by the oil and being heavier than water sinks to the bottom of the containing vessel and may be disposed of as desired.

The process of the other class, called in the record the "Metal Sinking Process," reverses the action of the Surface

Flotation Process and is illustrated by the Cattermole U. S. patent, No. 777,273, in which oil is used to the extent of 4 per cent to 6 per cent to 10 per cent of the weight of the metalliferous mineral matter, depending on the character of the ore, for the purpose of agglomerating the oil-coated concentrate into granules heavier than water, so that they will sink to the bottom of the containing vessel, permitting the gangue to be carried away by an upward flowing stream of water.

The process of the patent in suit, as described and practised, consists in the use of an amount of oil which is "critical" and minute as compared with the amount used in prior processes "amounting to a fraction of 1 per cent of the ore," and in so impregnating with air the mass of ore and water used, by agitation—"by beating the air into the mass"—as to cause to rise to the surface of the mass, or pulp, a froth, peculiarly coherent and persistent in character, which is composed of air bubbles with only a trace of oil in them, which carry in mechanical suspension a very high percentage of the metal and metalliferous particles of ore which were contained in the mass of crushed ore subjected to treatment. This froth can be removed and the metal recovered by processes with which the patent is not concerned.

It is obvious that the process of the patent in suit, as we have described it, is not of the Metal Sinking class, and while it may, in terms, be described as a Surface Flotation Process, yet it differs so essentially from all prior processes in its character, in its simplicity of operation and in the resulting concentrate, that we are persuaded that it constitutes a new and patentable discovery.

The prior processes which we have described required the use of so much oil that they were too expensive to be used on lean ores, to which they were intended to have their chief application, and the efforts of investigators for several years prior to the discovery of the process in suit had been directed to the search for a means or method of reducing the amount of oil used, and it is clear from the record that approach was being made, slowly, but more and more nearly to the result which was reached by the patentees of the process in suit in March, 1905. The Froment Great Britain patent (1903) and the Kirby United States patent (applied for in 1903 and granted in 1906) are especially suggestive of the advance which was being made toward the desired result, but the Froment process was little more than a laboratory experiment and has never proved of value in practice, and the Kirby process, though approaching in some respects more nearly to the end attained by the process of the patent in suit, found its preferred application in the use of an amount of oil solution equal to one-fourth to three-fourths in weight of the ore treated, which was prohibitive in cost.

Into this field of investigation at this stage of its development came the patentees of the patent in suit. They were experienced metallurgists of London, of inventive genius and with financial resources, and they entered upon an investigation of the processes of oil concentration of ores which was continued through several years, and consisted of a very extended series of experiments in which the quantities of oil, of water and of acid used and the extent and character of the agitation of the mass under treatment resorted to, were varied to an almost unparalleled extent as to each factor and the results were carefully tabulated and interpreted. It was while pursuing a comprehensive investigation of this character, having, as the evidence shows, the special purpose in mind at the time to trace the effect on the results of the process of a reduction to the vanishing point of the quantity of oil used, that the discovery embodied in the patent in suit was made.

The experimenters were working on the Cattermole "Metal Sinking Process" as a basis when it was discovered that the granulation on which the process depended practically ceased when the oleic acid (oil) was reduced to about 5 per cent "on the ore." It was observed, however, that, as the amount of oleic acid was further reduced and the granulation diminished, there was an increase in the amount of "float froth," which collected on the surface of the mass and that the production of this froth reached its maximum when about 1 per cent or slightly less "on the ore" of oleic acid was used. This froth, on collection, was found to consist of air bubbles modified by the presence of the minute amount of oil used and holding in mechanical suspension between 70 per cent and 80 per cent of the total mineral content of the mass treated. It was promptly recognized by the patentees that this froth was not due to the liberation of gas in the mass treated by the action of the dilute acid used, and its formation was at once attributed in large part to the presence of the air introduced into the mixture by the agitation which had been resorted to to mix the oil with the particles of crushed ore, which air, in bubbles, attached itself to the mineral particles, slightly coated as they

were with what was necessarily an infinitesimal amount of oil, and floated them to the surface. The extent of the agitation of the mass had been increased as the experiments proceeded until the "series of Gabbett mixers, fitted with the usual baffles, were speeded at from 1000 to 1100 revolutions per minute."

A careful consideration of the record in this case convinces us that the facts with respect to the process of the patent in suit are not overstated by the plaintiffs' witness, Adolph Liebmann, an expert of learning and experience, when he says in substance:

"The present invention differs essentially from all previous results. It is true that oil is one of the substances, but it is used in quantities much smaller than was ever heard of, and it produces a result never obtained before. The minerals are obtained in a froth of a peculiar character, consisting of air bubbles which in their covering film have the minerals embedded in such manner that they form a complete surface all over the bubbles. A remarkable fact with regard to this froth is that, although the very light and easily destructible air bubbles are covered with a heavy mineral, yet the froth is stable and utterly different from any froth known before, being so permanent in character that I have personally seen it stand for twenty-four hours without any change having taken place. The simplicity of the operation, as compared with the prior attempts, is startling. All that has to be done is to add a minute quantity of oil to the pulp to which acid may or may not be added, agitate for from two and one-half to ten minutes and then after a few seconds collect from the surface the froth which will contain a large percentage of the minerals present in the ore."

It is not necessary for us to go into a detailed examination of the process in suit to distinguish it from the processes of the patents relied on as anticipations, convinced as we are that the small amount of oil used makes it impossible that the lifting force which separates the metallic particles of the pulp from the other substances of it is not to be found principally in the buoyancy of the oil used, as was the case in prior processes, but that this force is to be found chiefly in the buoyancy of the air bubbles introduced into the mixture by an agitation greater than and different from that which had been resorted to before and that this advance on the prior art and the resulting froth concentrate so different from the product of other processes make of it a patentable discovery as new and original as it has proved useful and economical.

It results without more discussion, that we fully agree with the decision of the House of Lords, arrived at upon a different record and with different witnesses, but when dealing with the equivalent of the patent in suit, in *Minerals Separation, Limited, v. British Air Concentration Syndicate, Limited*, 27 R. P. C. 33. In this decision Lord Shaw, speaking for the court and distinguishing the process there in suit especially from the Elmore oil flotation process which had gone before but which was typical of the then prior art said: "They (the patentees of the Agitation Froth Process of the patent in suit) are not promoting a method of separation which had before been described, but they are engaged upon a new method of separation. Instead of relying upon the lesser specific gravity of oil in bulk they rely upon the production of a froth by means of an agitation which not only assists the process of the minute quantities of oil reaching the minute particles of metal, but forms a multitude of air cells, the buoyancy of which air cells, forming around single particles of the metal, floats them to the surface of the liquid."

And Lord Atkinson said: "In the process this mysterious affinity of oil for the metallic particles of the ore is availed of, yet the oil is used in such relatively infinitesimal quantities that the metallic particles are only coated with a thin film of it, and the lifting force is found not in the natural buoyancy of the mass of added oil, but in the buoyancy of air bubbles, which, introduced into the mixture by the more or less violent agitation of it, envelop or become attached to, the thinly oiled metallic particles, and raise them to the surface, where they are maintained by what is styled the surface tension of the water."

The record shows not only that the process in suit was promptly considered by the patentees as an original and important discovery, but that it was immediately generally accepted as so great an advance over any process known before that, without puffing or other business exploitation, it promptly came into extensive use for the concentration of ores in most, if not all, of the principal mining countries of the world, notably in the United States, Australia, Sweden, Chile and Cuba, and that, because of its economy and simplicity, it has largely replaced all earlier processes. This, of itself, is persuasive evidence of that invention which it is the purpose of the patent laws to reward and protect.

Diamond Rubber Co. v. Consolidated Tire Co., 220 U. S. 428; *Carnegie Steel Co. v. Cambria Iron Co.*, 185 U. S. 403, 429, 430; *The Barbed Wire Patent*, 143 U. S. 275; *Smith v. Good-year Dental Vulcanite Co.*, 93 U. S. 486.

The claim that the patentees of the patent in suit are not the original discoverers of the process patented because an employee of theirs happened to make the analysis and observations which resulted immediately in the discovery, cannot be allowed. The record shows very clearly that the patentee planned the experiments in progress when the discovery was made; that they directed the investigations day by day, conducting them in large part personally and that they interpreted the results. *Agawam Company v. Jordan*, 7 Wall, 583-603, rules this claim against the defendant.

Equally untenable is the claim that the patent is invalid for the reason that the evidence shows that when different ores are treated, preliminary tests must be made to determine the amount of oil and the extent of agitation necessary in order to obtain the best results. Such variation of treatment must be within the scope of the claims, and the certainty which the law requires in patents is not greater than is reasonable, having regard to their subject matter. The composition of ores varies infinitely, each one presenting its special problem, and it is obviously impossible to specify in a patent the precise treatment which would be most successful and economical in each case. The process is one dealing with a large class of substances and the range of treatment within the terms of the claims, while leaving something to the skill of persons applying the invention, is clearly sufficiently definite to guide those skilled in the art to its successful application, as the evidence abundantly shows. This satisfies the law. *Mowry v. Whitney*, 14 Wall. 620; *Ives v. Hamilton*, 92 U. S. 426, and *Carnegie Steel Co. v. Cambria Iron Co.*, 185 U. S. 403, 436, 437.

The evidence of infringement is clear.

While we thus find in favor of the validity of the patent, we cannot agree with the District Court in regarding it valid as to all of the claims in suit. As we have pointed out in this opinion, there were many investigators at work in this field to which the process in suit relates when the patentees came into it, and it was while engaged in study of prior kindred processes that their discovery was made. While the evidence in the case makes it clear that they discovered the final step which converted experiment into solution, "turned failure into success" (*The Barbed Wire Patent*, 143 U. S. 275), yet the investigations preceding were so informing that this final step was not a long one and the patent must be confined to the results obtained by the use of oil within the proportions often described in the testimony and in the claims of the patent as "critical proportions" "amounting to a fraction of 1 per cent of the ore," and therefore the decree of this court will be that the patent is valid as to claims Nos. 1, 2, 3, 5, 6, 7 and 12, and that the defendant infringed these claims, but that it is invalid as to claims 9, 10 and 11. Claims No. 4, 8 and 13 were not considered in the decree of the two lower courts and are not in issue in this proceeding.

The decision of the Circuit Court of Appeals will be reversed, and the decision of the District Court, modified to conform to the conclusions expressed in this opinion, will be affirmed.

Bureau of Standards to Study Refractories.—The Bureau of Standards has begun an investigation of clay refractories in co-operation with the American Refractories Manufacturers' Association and the American Gas Institute. The bureau also has begun preliminary work on another investigation dealing with a phase of the same industry, using a dolomite in certain metallurgical furnaces as a refractory. Usually the burned dolomite is placed directly in position in the furnace with tar or some other combustible material as a binder. Where the lining was of such a nature that it had to be made of brick, magnesite brick was used. The price of magnesite brick, however, has advanced to such a degree that the use of this material has become almost prohibitive. It has been suggested at various times that dolomite might be burned in such a manner, or with the addition of such impurities that the lime present in it would not slake, except after an extended period, making it possible to produce a brick of this material which would replace the magnesite brick. The bureau by its investigation will determine the possibility of producing such a burned dolomite.

Current Efficiency in Copper Refining

By Lawrence Addicks

Current efficiency in an electrolytic operation is the ratio between the weight of product obtained per ampere hour and that called for by Faraday's law, for the current used in the desired reaction. It has therefore much to do with the cost of operations, but in this connection it must be considered jointly with the voltage factor; for example, the series system in copper refining operates at a lower current efficiency than the multiple and yet yields a greater weight of cathode per kilowatt-hour expended in the cell. For any given case, however, it is desirable to obtain as high a current efficiency as may be consistent with the cost of securing it, and it is our purpose to examine this question in its bearing to the multiple system of electrolytic copper refining.

The percentage which we obtain by dividing the weight in grams of cathode per ampere hour by 1.186 is less than 100 because part of the current performs no electrolytic operation on account of leakage or short circuits between electrodes, part is involved in reactions not desired and a portion of the cathode itself is redissolved chemically. It is even possible to obtain apparent efficiencies above 100 per cent under certain conditions.

In order to secure an exact correspondence with Faraday's law various niceties of operation must be observed and a great deal of study in this direction has been applied by those interested in voltmeter measurements. It is quite possible, however, with care and dismissal of questions of labor cost, to obtain a working efficiency on a large scale of 99 per cent. Commercially it is found, however, that about 92 per cent is as high a figure as it is advisable to insist upon and at some plants 90 per cent or even 88 per cent is considered satisfactory. Current density has a direct bearing on the problem in that a high density greatly increases the difficulty in preventing short circuits between the electrodes.

The various factors involved may be classified as follows:

A. Current leakage:

- a. To ground.
- b. Through electrolyte.
- c. Between electrodes.

B. Reaction:

- a. Deposition of impurities.
- b. Gassing.
- c. Valence.

C. Cathode shrinkage:

- a. Sulphatizing.
- b. Ferric salts.
- c. Nodules, etc.

A. Current Leakage

(a) *To Ground.*—The insulation resistance of the circuit from the ground may be determined by noting the reading of a high-resistance voltmeter when connected from either switch terminal on the live circuit to the ground by a simple application of Ohm's law. The current flowing through the voltmeter is obtained by dividing its reading by its known resistance; the total resistance in the leakage circuit is obtained by dividing the known line voltage by this current; the insulation resistance is found by subtracting the known voltmeter resistance.

It is evident that the resistance found in this way is a measure of the obstacles in the path of the current from the ground back through improper channels to

the other leg of the circuit, and that by opening the main circuit at predetermined points and taking repeated measurements a leakage map could be worked out. This, however, should not be necessary, as while the insulation resistance of an electrolytic circuit will always be low—a usual value is five ohms—the actual loss of effective current from this source is a minor matter in any plant where the foundation piers are properly capped with glass plates and tank leaks kept from resulting in sulphate crystals climbing around promiscuously.

If we assume that a circuit has a total resistance of five ohms from one side to the other through the ground and that the line voltage is 150, this leakage will be but 30 amp. If the main current is 10,000 amp. and the leakage uniformly distributed so that it robbed an average of but half the tanks, the percentage loss would be but 0.15 per cent.

(b) *Through Electrolyte.*—There are three ways of determining the loss of effective current due to improper shunt circuits through the circulation system: by direct measurement, by Ohm's law calculations and by Faraday's law calculations.

The direct method consists of placing carefully calibrated ammeters at various points in the circuit and comparing their readings, which would be identical except for losses under (a) and (b). Considerable care is required to avoid errors in measurement as thermoelectric effects may creep into the temporary shunt connections and magnetic errors, due to strong stray field, may distort the meter readings even when the instruments are protected by iron cases. An unprotected portable instrument may even be permanently thrown out of adjustment by exposure of its permanent magnets to the action of the stray field which exists within a couple of feet of a conductor carrying 10,000 amp.

Another method is to open the circuit in the center and note how many amperes are recorded by the powerhouse ammeter when full voltage is applied. This is not fair in that the voltage distribution throughout the circuit is not normal.

It will generally be found that the tanks at the far end of a circuit receive 3 or 4 per cent less than the switchboard current.

Ohm's law calculations may be made upon the liquid columns of electrolyte, as we know the resistance per cubic inch of the liquor, its physical dimensions and the voltages operating. Where the voltages are sufficiently low the lead pipe cannot act as a conductor, as when the current leaves it there must be sufficient voltage to decompose water. When such voltages occur sections of hard rubber or of rubber hose are employed to break the continuity of the metal path. It is also possible to take fall of potential readings along a lead pipe and figure the current flowing therein by Ohm's law and the specific resistance of hard lead.

Finally, we know that wherever the current enters the piping system it must deposit Faraday's equivalent of copper. This is of great practical assistance, as while it gives no information regarding the current flowing in the liquid itself, it does bring to daily attention any abnormal participation of the conduit system, and the accumulation of copper trees demands early attention to avoid stopping up the pipes.

The coating of lead sulphate which covers all tank linings and pipes exposed to the action of the electrolyte acts as an insulating paint of much value, as shown by the low efficiencies always obtained in starting up a new installation of bright tanks. A final insulating joint is usually effected where the electrolyte leaves a tank by allowing it to fall freely into the launder without a containing pipe for some inches.

Altogether ample means exist for measuring and controlling this source of loss.

(c) *Between Electrodes*.—The direct touching of anode and cathode is the most usual cause of poor efficiency. This condition can be brought about by the electrodes being carelessly spaced in the tank, by the curling of starting sheets, by falling of anode scrap, by omission of electrode insulators, by electrodes displaced sideways so as to touch the lead lining of the tank, by "treeing" of the cathode deposit, by the accumulation of an excessive quantity of slimes in the bottom of the tank or by the careless leaving of tools lying on top of the electrodes.

It is obvious that with the exception of "treeing" and falling anode scrap these causes may be removed in proportion to the amount of labor and inspection applied. Treeing involves the control of the cathode deposit by the choice of a suitable cathode age for the current density employed, adequate circulation of the electrolyte and the use of additional agents.

A cathode deposit starts as a fine frosting, and with a violent circulation this builds up with perfect smoothness. It is not possible to employ even a rapid circulation, however, on account of the consequent stirring up of anode slimes, and any mechanical scouring effect is therefore lost. On the other hand, the circulation must be maintained at a rate sufficient to supply copper ions at the cathode as fast as demanded by the current density, or other ions will act as carriers of the current and the deposit will become rough and non-adherent. Even under normal conditions fine needles soon spring out in crystal formation. The moment the cathode surface becomes roughened the parts nearest the anode offer the path of least resistance to the current and bad soon becomes worse.

The function of addition agents is first to round off these needles into blunt nodules, and second to change what is called "cocoa matting" structure to a hard compact deposit. Ordinary lubricating oil possesses some property which effects the first and minute quantities of glue the second.

The falling apart of scrap anodes results from incomplete refining of the blister copper in the anode furnace. As the condition causes an abnormal quantity of scrap and leaks from pierced tank linings as well as low-current efficiency the remedy lies in better furnace treatment.

A short circuit between two electrodes is not as serious as at first appears because there is a certain resistance due to conductors and contacts in series with each electrode and a number of parallel circuits. For example, if we have thirty pairs of electrodes and the series resistance amounts to one-quarter of the total across the tank, it is evident that a reduction of 75 per cent of the resistance in one of the thirty parallel circuits will but make it equal to four normal circuits out of the thirty and not draw any great share of the current. Then the increased current flow heats the conductors and contacts affected, and this increases their resistance. Finally, there is a certain rebate on the voltage side due to the lowered resistance of the tank when it comes to pounds of cathode per kilowatt-hour.

In general an economic balance is struck when about 5 per cent of the current is rendered non-effective by local short circuits.

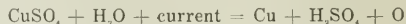
B. Reaction

(a) *Deposition of Impurities*.—In the ordinary depositing tank the current consumed in the direct deposition of impurities is obviously negligible, as appears from the great purity of the cathode; in fact, it is an open question whether any of the traces of impurities

found in cathode copper are due to electrolytic action. Where insoluble or partly soluble anodes are used and higher voltages obtain, this item becomes measurable. An example of the first case is where arsenic is deposited in a "liberator" tank in copper refining, and of the second where iron is deposited in a copper-nickel refinery.

(b) *Gassing*.—A copper cathode rarely shows upon analysis above 99.95 per cent copper. The metallic impurities may total 0.02 per cent, still leaving some unaccounted for difference. Part of this is included electrolyte, but after all allowances are made it seems probable that hydrogen is present either as hydride or by occlusion. We know that some addition agents harden the cathode, and that this hardness may be removed by annealing. When all the copper in a liquor is plated out, as in the case of an electrolytic assay, the gassing does not begin and the voltage rise suddenly upon the exhaustion of the copper, but some gassing starts early and the voltage gradually rises. In the same way local conditions at the cathode due to the moderate circulation employed may cause the separation of a certain amount of hydrogen at the cathode in a normally operating cell. It seems probable, therefore, that a small proportion of the current may be diverted into depositing hydrogen instead of copper, and even a minute quantity of hydrogen will account for a measurable current on account of its very low electrochemical equivalent. For example, 0.03 per cent of hydrogen would take 0.9 per cent of the current. We do not know how much of a source of loss this condition is in straight copper work, but in nickel deposition it may be enormous, free hydrogen appearing in quantity at the cathode.

(c) *Valence*.—The efficiency is based upon the reaction



where copper acts as a divalent metal. It is evident that should the copper in the electrolyte be present in a cuprous salt, copper might be precipitated at an apparent efficiency of 200 per cent. Cuprous salts are undoubtedly formed to a certain extent at the anode, as shown by the cuprous chloride and metallic dust found in the slimes resulting from such a reaction as $\text{Cu}_2\text{SO}_4 = \text{CuSO}_4 + \text{Cu}$, although the latter is partly due to $\text{Cu}_2\text{O} + \text{H}_2\text{SO}_4 = \text{CuSO}_4 + \text{H}_2\text{O} + \text{Cu}$.

Cuprous sulphate is very unstable or we should gladly use it as the basis of an electrolyte, and it seems very unlikely that an appreciable amount exists at the cathode. The cuprous chloride found in the cathode when excess chlorides are allowed to accumulate in the electrolyte is doubtless due to direct reduction by the cathode as $\text{CuCl}_2 + \text{Cu} = 2\text{CuCl}$.

C. Cathode Shrinkage

(a) *Sulphatizing*.—A certain amount of the deposited copper is redissolved by the electrolyte. While copper is not normally soluble in dilute sulphuric acid, the oxygen dissolved in the electrolyte aids in a slow attack— $\text{Cu} + \text{H}_2\text{SO}_4 + \text{O} = \text{CuSO}_4 + \text{H}_2\text{O}$ probably expresses the complete reaction. As would be expected the action is particularly marked at the solution line and various expedients, such as painting or changing the solution level, have to be employed in order to prevent the cathode loops cutting through at the solution line.

The amount of this chemical action is indicated by the growth in the copper content of the electrolyte after correcting for anode impurities dissolving electrolytically and cuprous oxide in the anode dissolving chemically, and it is found to increase rapidly with increase of temperature of the electrolyte.

A fair figure is about 2 per cent of the deposited copper, and if we assume that half of this came from the anodes we have an apparent loss in current efficiency of 1 per cent.

(b) *Ferric Salts*.—If the anodes are not free from iron, converter anodes, for instance, and the resulting ferrous sulphate is allowed to accumulate in the electrolyte, there is a tendency, increasing with concentration, for this salt to be oxidized at the anode— $2\text{FeSO}_4 + \text{H}_2\text{SO}_4 + \text{O} = \text{Fe}_2(\text{SO}_4)_3 + \text{H}_2\text{O}$. This is particularly the case in insoluble anode tanks where the ferrous sulphate acts as a true depolarizer. This ferric salt is again reduced, either electrically at the cathode— $\text{Fe}_2(\text{SO}_4)_3 + 2\text{H} = 2\text{FeSO}_4 + \text{H}_2\text{SO}_4$ —or by the anodes and cathodes chemically— $\text{Fe}_2(\text{SO}_4)_3 + \text{Cu} = 2\text{FeSO}_4 + \text{CuSO}_4$. In either case there is a diversion of the current from its normal work and a corresponding loss in current efficiency. Under bad conditions, such as obtain in leaching copper ores, this loss may become very serious, but in straight refining work it should be entirely negligible.

(c) *Nodules, Etc.*—There is a certain apparent loss in efficiency due to mechanical shrinkage of the cathode from nodules falling into the slimes, chiefly due to inspection work on the tanks. This material is screened out of the slimes later, but is too contaminated to be considered legitimate production. Unless the deposit is rough the amount of this shrinkage will be but a small fraction of 1 per cent.

Summary

The nine sources of efficiency loss are always present, but any or all of them can be kept down to a very small quantity. On the other hand, most of them may become very serious under undesirable conditions. In general we can say that entire disregard of conditions may result in an efficiency as low as 60 per cent, poor work 85 per cent, good balanced operating 92 per cent, and efficiency regardless of expense 99 per cent.

Big Development Expected in Canadian Pulp and Paper Industry.—The large and increasing export of pulp to the American market is expected to cause great expansion of the Canadian pulp and paper industry. Several new plants are being erected and others are under consideration. Canada has the timber and waterpower and comparatively cheap labor to manufacture successfully. Canada will also have a large British market, including Australia and Africa.

Trade Agreements.—The Chamber of Commerce of the United States has received the report of the special committee, recommending that co-operative agreements be permitted under Federal supervision, where natural resources are involved. A condition is imposed, viz., that the agreements tend to conserve the resources and promote safety work. The report has been submitted to several commercial organizations for approval. The plan would empower the Federal Trade Commission to provide a method under which an industry may operate to the common benefit of producers, consumers and workmen. W. L. Saunders, chairman of the board of the Ingersoll-Rand Co., is chairman of the committee.

Manufacturers of Oxygen and Hydrogen in Germany Combine.—The leading oxygen and hydrogen producers in Germany, viz.: The Griesheim-Elektron Co., the Linde Refrigerating Machinery Co. and the German Oxyhydric Co., which between them control about 30 factories have formed a selling combine. Oxygen is said to be selling for 70 pfennig per cubic meter to private consumers and hydrogen for 40 pfennig.

The Nature and Origin of Petroleum and Asphalt

By Clifford Richardson

The writer has advanced the theory* that the origin of petroleum is to be attributed to relations of surfaces and films; that is to say, of films of certain types of natural gas, either as gas or, under pressure at the levels where it exists, in a liquid state, to surfaces of solids, the oil "sands" with which the former comes in contact at considerable depth below the earth's surface. The correctness of this theory seems to be emphasized by the fact that petroleum, wherever it occurs, is accompanied in the "sands" by gas in greater or less amounts, in many cases, in considerable excess. In regard to the origin of the gas no attempt will be made to draw a definite conclusion, as too little evidence is available to permit doing so.

While the writer's conception in regard to the origin of petroleum is purely theoretical, it is suggested and confirmed by studies of the nature and origin of one of the more solid forms of bitumen, that of the asphalt found in the well-known pitch lake in the Island of Trinidad, British West Indies. It appears that a petroleum, existing at considerable depth at that point, is converted to a more solid form of bitumen, asphalt, by coming in contact and being thoroughly emulsified with an aqueous paste consisting of clay, in a colloidal state as regards water, and very fine sand, which is in a colloidal state as regards the highly viscous bitumen. The clay and sand occur as a mud in a spring through which the oil breaks out before reaching the surface and with which it becomes intimately associated, owing to the strong evolution of gas which accompanies the oil as the pressure is released.

The deposit lies in a bowl-like depression, evidently the crater of an old mud spring or volcano, covering a superficial area of about 114 acres and having a depth of more than 135 ft., as shown by a boring made with a wash drill. The boring was necessarily discontinued at this depth, as, owing to the movement of the pitch, the pipe so far departed from the perpendicular as to prevent further work. This movement is due to the evolution of gas on the release of the pressure, to which it has been subjected, on reaching the surface, which is an original component of the petroleum as it is found in the oil "sand." The entire surface of the deposit is in constant motion. It is sufficiently solid to permit of driving a horse and cart over it, and to support, with constant attention, a railroad track for gathering and shipping the asphalt. From its form and environment it is known as a lake. It lies about half a mile from the sea at an elevation of 138 ft. above it.

The material of the deposit is a most unique geophysical phenomenon. At whatever point on the surface or whatever depth it is collected it is found to be of extremely uniform character, as appears from the following data:

AVERAGE COMPOSITION OF TRINIDAD LAKE PITCH IN CIRCLES

	Bitumen by CNS, per Cent	Mineral Matter, per Cent	Undetermined, per Cent
Circle 2, 200 ft. from center.	55.02	35.41	9.57
Circle 4, 400 ft. from center.	54.99	35.40	9.61
Circle 6, 500 ft. from center.	54.84	35.49	9.67
Circle 8, 800 ft. from center.	54.06	35.56	9.78
Circle 10, 1000 ft. from center.	54.78	35.44	9.78
Circle 12, 1100 ft. from center.	54.62	35.45	9.93
General average	54.92	35.46	9.72
Circle 14, 1400 ft. from center.	53.86	36.38	9.76
At a depth of 135 feet	54.66	35.90	9.44

*Jour. Ind. & Eng. Chem., Vol. 8, No. 1, page 4, 1916.

In the preceding figures data are given in regard to material, one component of which, water, has been removed by pulverizing and exposure to the air. As a matter of fact, the water present is as constant in amount, 29 per cent, as that of the other components. It is evident that the conditions under which the asphalt is formed involve a state of equilibrium between the components.

Including the water, the composition of the asphalt is as follows:

	Crude Trinidad Asphalt, per Cent
Water and gas.....	29.0
Bitumen soluble in cold carbon disulphide.....	39.0
Bitumen adsorbed and retained by the disperse mineral matter.....	0.3
Mineral matter on ignition with tricalcium phosphate.....	27.2
Water of hydration of clay.....	4.2

There is a constant influx of new material into the deposit near its center. This is, however, of different character from the main mass. It is, evidently, a freshly formed emulsion of the petroleum and the mud of the spring through which the oil rises to the surface. As a result it is of a very soft character, and can be readily molded in the hands, containing an excess of water not a part of the emulsion. In the course of years this soft material hardens and becomes of the consistency of the main mass of the deposit. This is, no doubt, to be attributed to the surface action which goes on between the colloidal mineral matter and the oil with which it is associated, and it has been observed that where the asphalt has overflowed the rim of the deposit and been exposed, probably for centuries, the surface action has gone further and the bitumen has been converted to a harder form than that found in the main deposit; in fact, differences in this respect can be found between the material near the center of the main deposit and that near its edge.

The origin of this asphalt having been demonstrated to depend upon the relations between heavy petroleum and mineral matter in a colloidal state, the origin of the petroleum itself, it seems reasonable to infer, is to be attributed to a similar condition of affairs in which the natural gas, from its relation to the surfaces of the oil "sand," is converted into petroleum.

It must, of course, be recognized that the surface action going on between a dense petroleum and mineral matter, much of it in a colloidal state as regards water, must be a much more rapid one than between a natural gas and a coarser oil "sand" with which it is brought in contact. But within long periods of time the latter must be quite similar to the former and should account for the origin of petroleum, especially in view of the fact that natural gas consists principally of methane and ethane.

Some natural gases contain hydrogen-sulphide and carbon-dioxide. From the first the petroleum containing sulphur should be derived, although they can also originate in the contact of the oils with sulphur and its compounds existing in the oil "sands"; in fact, free sulphur has been isolated from a Texas petroleum. Carbon-dioxide is an unusual constituent of natural gas, although it occurs in California in a McKittrick well to the extent of 30 per cent. In some of the gases in Trinidad, however, it exists in considerable amount, reaching 33 per cent in a gas which occurs in wells near the asphalt deposit. It is worthy of note also, that in the limited area in which oil wells have been sunk the gas encountered is of very variable composition. Analyses of a number of them, furnished by the writer, have

been made by the U. S. Bureau of Mines, which afford the following data:

COMPOSITION OF GAS FROM TRINIDAD, B. W. I.						
Identification No.	CH ₄	C ₂ H ₆	CO ₂	O ₂	N ₂	H ₂ S
1	85.1	4.1	9.8	.0	1.0	.0
2	73.2	4.0	20.0	.0	1.0	.8
3	64.7	4.7	26.3	.0	2.7	1.6
4	34.8	27.8	33.5	.0	.4	3.5
5	51.2	15.8	32.0	.0	1.0	.0
6	88.0	10.1	1.7	.0	.2	.0
7	32.4	32.6	25.1	.0	.4	8.7

IDENTIFICATION OF SAMPLES

From Surface of Asphalt Deposit:

1. At center of lake.
2. Where gas bubbles issue violently from surface water at center of lake.
3. Where small bubbles issue gently from surface water at center of lake.

From Oil Wells:

4. Near lake.
5. From well No. 3, 1¼ miles southeast of lake.
6. From well No. 37, 3¼ miles south of lake.
7. From well No. 48, near lake.

In connection with the preceding figures showing the composition of the gases of Trinidad which are closely associated with the formation of asphalt, an examination of that of others from various fields is of interest.

COMPOSITION OF NATURAL GAS*							
State	Location	CH ₄	C ₂ H ₆	CO ₂	O ₂	N ₂	B.T.U.
Cal.	Santa Maria.....	62.7	20.2	15.5	.2	1.4	1,044
Cal.	Torrey.....	54.2	35.6	6.8	.0	3.4	1,240
Cal.	Coolidge.....	88.0	.0	11.1	.0	.9	937
Cal.	McKittrick.....	66.2	1.0	30.4	.0	2.4	724
Cal.	W. Los Angeles.....	91.0	2.7	1.0	.1	5.2	1,019
Cal.	Sunset.....	87.7	.0	10.5	.0	1.8	934
Cal.	Fullerton.....	86.7	9.5	1.7	.0	2.1	1,100
Cal.	Kern River.....	84.3	8.0	6.5	.0	1.2	1,047
Pa.	Clarion Co.....	96.4	2.5	.0	.0	1.1	1,073
Pa.	Forest Co.....	70.8	28.2	.0	.0	1.0	1,279
Pa.	Clarion Co.....	80.5	17.8	.0	.0	1.7	1,189
Pa.	Butler Co.....	53.3	45.8	.0	.0	.9	1,420
Pa.	Armstrong Co.....	81.6	16.9	.1	.0	1.5	1,184
Okl.	Osage Co.....	94.3	.0	1.1	.0	4.6	1,004
Okl.	Creek Co.....	64.1	31.7	2.4	.0	1.8	1,273
Ky.	Barren Co.....	23.6	69.7	2.5	.0	1.3a	1,548
Ky.	Barren Co.....	44.1	48.2	2.6	.0	5.1b	1,367
Utah.	Grand Co.....	90.8	.0	3.6	.0	5.6	967
Utah.	Grand Co.....	90.0	.0	3.5	.0	6.5	959
Ore.	.....	96.1	.0	3.0	.0	0.9	1,023
Pa.	Crawford Co.....	6.6	91.1	.0	.0	2.3	1,765
Ore.	Tallamook Co.....	2.0	.0	.1	.0	97.9	21
Nev.	Churchill Co.....	65.6	.0	1.3	.0	3.1	1,018
Ohio.	Cuyahoga.....	80.5	18.2	.0	.0	1.3	1,196
Ohio.	Franklin.....	80.4	18.1	.0	.0	1.5	1,193
Ohio.	Hamilton.....	79.8	19.5	.0	.0	.7	1,213
N. Y.	Eric Co.....	79.9	15.2	.0	.0	4.9	1,134
Mo.	Jasper Co.....	92.6	1.3	.0	.0	2.5	1,066
Ky.	Jefferson.....	77.8	20.4	.0	.0	1.8	1,205
Texas.	Dallas.....	50.6	10.9	.1	.0	38.4	742
Okl.	Nowata Co.....	96.5	.0	1.3	.0	2.2	1,038

*Bulletin 88, U. S. Bureau of Mines, page 21.

a—H₂S, 2.9 per cent. b—H₂S, 0.1 per cent.

The California gases which are associated with highly asphaltic oils are nearly as variable as those of Trinidad in the percentages of methane and ethane present. They are also characterized by the fact that they carry considerable percentage of carbon-dioxide, in one case as high as 30.4 per cent. One contains a considerable percentage of hydrogen sulphide and the other carries none. In the Oklahoma and Kentucky gases, from which originate petroleum of a semi-asphaltic nature, carbon-dioxide is present to a notable extent. In the gas associated with the purely paraffine oils of Pennsylvania this gas is not found. The question arises whether its presence bears any relation to the formation of asphaltic petroleum. That of hydrogen sulphide might be regarded as having something to do with such a form were it not for the fact that it is absent from the Cali-

formia gases. The main mass of the gases from the various fields consists of methane and ethane, notwithstanding which fact the petroleum derived from them are markedly different in their characteristics. In the writer's opinion, this leads to the conclusion that the character of the petroleum derived from natural gas is to an important degree dependent upon that of the surface of the oil "sands" with which the gas contacts.

This is the thesis upon which the writer's theory of the origin of petroleum is founded; that is to say, while the gas from which petroleum originates is largely a mixture of methane and ethane, the petroleum originating from these gases varies in character, depending upon the state of subdivision and character of the surface presented to the gases by the "sands" and with which they come in contact. The result is, of course, influenced to a certain degree if the natural gas contains hydrogen sulphide, and apparently, also, to a considerable extent if there is a larger percentage of carbon-dioxide present, in this case asphaltic oils being formed.

In certain fields natural gas occurs which is not associated with petroleum. In this case it must be assumed that the gas does not remain in contact with the "sands" for a sufficient length of time to accomplish this, or the surfaces are not such in area or in character as will bring about its condensation to petroleum, the time factor being an important one.

New York City

New Developments in Nickel Industry.—The new refinery of the International Nickel Company in Wexford, Ontario, will be completed in about twelve months. Actual operations on the building of another refinery for the British-American Company will soon be commenced. These developments will make greater demands on Ontario for nickel ore. The value of the nickel output of Canada for 1916 is estimated to be \$23,000,000. The first and largest producer is the International Nickel Co. (Ambrose Monell, President), which does its refining in New Jersey, but smelts the matte in Sudbury, through the Canadian Copper Co., which it controls. The other corporation is the Mond Nickel Co. of Great Britain, whose head is Sir Alfred Mond, the prominent Liberal member of the British House of Commons. The Mond Nickel Co. also smelts its ore into matte at Coniston, Ont., and the matte is refined at Clydach, Wales, those works being greatly enlarged in 1914. The International Nickel Co. takes practically all of the 59,000,000 pounds which is shipped to the United States, and the Mond Co. all of the 12,000,000 pounds, which goes to Great Britain.

A third corporation was organized in July, 1913, under the name of the Canadian Nickel Corporation, but in the following month the name was changed to the British-American Nickel Corporation, and its plans are now taking more definite shape. The company bought up the nickel interests of the late John R. Booth and others, and now controls 17,000 acres of Sudbury lands, and has obtained the Canadian rights to a Norwegian process known as the Hybinette (after the name of one of the members of Hybinette, Borthen & Henriksen, who operate the only large successful mine of Norway at Evje, refining at Christiansand). It is claimed that with this process nickel can be produced 99 per cent pure. The nominal capital of all the Canadian nickel companies is about \$100,000,000. The capital of the International Nickel Co. is \$62,000,000, but of this only \$2,500,000 is in the Canadian Copper Co. The capital of the British-American Nickel Corporation is \$30,000,000. Mr. E. P. Mathewson, the well known Anaconda metallurgist and manager of the Washoe Reduction Works, has gone to Canada to assume the management of the British-American Company.

The Utilization of Waste Heat for Steam-Generating Purposes*

(Concluded from Vol. XV, page 708)

Beehive Coke Ovens

While it is true that beehive coke ovens are gradually being replaced with by-product ovens, there are still a very large number of the former in operation. Since there are few, if any, coals from which good coke can be made in beehive ovens that cannot be satisfactorily coked in by-product ovens if properly handled, it is questionable whether more beehive ovens will ever be built. On the other hand, it will be a number of years before all of the existing beehive ovens can be replaced by the more modern type.

The total coke production of the country in 1913 was 46,300,000 net tons, and of this quantity the production of by-product ovens was 12,715,000 tons, or 27.5 per cent of the total. The total estimated production in 1916 is 55,000,000 net tons, of which approximately 19,000,000 tons, or 34.4 per cent, will be produced in by-product ovens. By 1918 it is estimated that the production from by-product ovens will be somewhat over 50 per cent of the total production of the country.

It is not in the province of the present paper to discuss the merits of the two systems. This class of waste heat is dealt with here because of the very remarkable results that are being secured from modern waste-heat boilers utilizing gases from beehive ovens, and because of the possibilities of saving, due to this utilization, until such time as beehive ovens are replaced. Furthermore, there are available figures from boiler installations made a number of years ago for this class of work, and from a comparison with the results secured to-day the great advance in the design of waste-heat boilers may be readily seen.

From the nature of the beehive oven coking process, the quantity of gas available from each oven is large. These weights will vary with the analysis of the coal coked and the class of coke being made. The analysis of the gases escaping from the individual ovens will vary widely during different periods of the coking operation. Where a large number of ovens, however, are connected by a single flue to a boiler, or boilers, the average analysis at the boiler entrance will not show a particularly wide variation due to the fact that different ovens in the range or block are at different stages of coke making. At certain periods during operation large quantities of carbon monoxide pass off from the ovens and burn in the flues; in no plant investigated has there been noticed any secondary combustion within the boiler. For estimating purposes, the gas weight available may be taken as from 6 to 7 lb. per pound of coal coked per hour.

The temperature of the gases leaving the individual ovens is high, probably averaging between 2000 and 2200 deg. The temperature of these gases as they enter any boiler that is installed will depend upon the length, design and location of the connecting flues. Some typical entering temperatures are given in Table 5.

As far as is known, the first water-tube boilers installed in this country for this class of waste-heat work were placed in operation in 1900 at Greensburg, Pa. Due to improper design of connecting flues, these boilers were not successful in the utilization of the waste gases, and shortly after their installation were changed to coal-fired boilers.

*A paper read before the American Society of Mechanical Engineers on Dec. 16, 1916, in New York. All temperatures in this paper are given in degrees Fahrenheit.

Rather complete figures are available from three different plants in which boilers are installed for this class of work, the first two representing early waste-heat practice and the third representing the modern waste-heat boiler.

TABLE V—RESULTS OF TESTS OF WASTE-HEAT BOILERS FOR BEEHIVE COKE OVENS

Test Number	1	2	3	4
Plant	Priestman Col. Ltd., Newcastle-on-Tyne	Frick Coal & Coke Co., York Run, Pa.	B. & W.	B. & W.
Location	Stirling	Stirling	Stirling	Stirling
Boiler	Stirling	Stirling	B. & W.	B. & W.
Heating surface, sq. ft.	1,610	10,800	10,200	10,200
Gas weight, lb. per hr.	23,200	83,650	125,500	155,100
Gas per hr. per sq. ft. of h.s., lb.	14.4	7.7	12.2	15.2
Temperatures:				
Gas entering boiler, deg. Fahr.	1,720 ¹	1,804	2,329	2,158
Gas leaving boiler, deg. Fahr.	650	490	463	477
Drop in temp., deg. Fahr.	1,070	1,314	1,866	1,681
Draft at boiler damper, in.	0.56	0.50	4.0	4.4
Draft at boiler inlet, in.	0.24	0.30	1.9	2.0
Draft loss, in.	0.32	0.20	2.1	2.4
Horsepower developed	187	824	1,756	1,956
Per cent of rated capacity	116	76	172	102
Approximate transfer rate (R)	4.7	3.2	5.6	6.8

¹Three boilers, each of 3600 sq. ft. heating surface.

²Temperature leaving ovens 1970 deg. Fahr.

The first plant is that of the Priestman Collieries, Ltd., near Newcastle-on-Tyne, England. Here a Stirling boiler, rated at 161 hp., was connected to 22 beehive ovens producing coke from an average of 3800 lb. of coal per hour for the 22 ovens, or 173 lb. per hour per oven.

The second is at the York Run, Pa., plant of the H. C. Frick Coke Company. In this installation there are three Stirling boilers having approximately 3600 sq. ft. of heating surface each, though the boilers were rated at the time of purchase as 300 hp. each. These three boilers were connected to a range of 50 ovens, and during the week devoted to boiler testing, there were on an average 44 ovens in service which were coking coal at the rate of 13800 lb. per hour, or 314 lb. per oven per hour.

It has not been possible to secure permission to name the owners of the third and distinctly modern installation, although they have kindly consented to the publishing of some of the results secured from the first unit put into service. This installation consisted of a Bab-

cock and Wilcox boiler 18 sections wide, each section being made up of twenty-six 20-ft. tubes and containing 10,200 sq. ft. of heating surface. The boiler is equipped with a superheater and furnished with a turbine-driven induced-draft fan.

During the time the tests were run on the Babcock and Wilcox boiler the ovens were being operated to meet plant demands for coke, some ovens making 24-hour, some 36-hour and others 48-hour coke. The speed of the fan connected to the Babcock and Wilcox boiler was regulated to handle an approximately constant weight of gas, and as ovens were cut in or cut out, other boilers would be put into service and taken off again when the gas weights were reduced. Because of this fact it was practically impossible to determine the actual amount of coal coked corresponding to the capacity developed by the Babcock and Wilcox boiler. It is possible, however, to check pretty definitely the gas weight passing through the boiler, and from this weight approximate the coking rate corresponding to the horsepower developed.

The performance of the first boiler unit has been so satisfactory that the owners have purchased, since its installation, six additional units for use with their ovens. These are similar to the one described, except that they are 27 sections wide instead of 18, each unit containing 15,300 sq. ft. of heating surface, or a total of 9180 hp. for the six units.

The results of two of a series of tests on this Babcock and Wilcox boiler, together with the results secured at the other two plants described, are given in Table 5. In this table the gas weights, while approximate, are certainly within 10 per cent of the actual weights.

The baffle arrangement in the boiler at the Priestman Collieries is not known. It is probable, however, that the gas-passage areas were somewhat larger than standard, as the draft loss through the boiler is considerably less than would be expected for an equal weight of gas in coal-fired practice. The exit temperature is high but, considering the design of boiler and the weight of gas, cannot be considered excessive. In the report covering the series of tests from which this was taken, a statement is made to the effect that the capacity obtained did not represent the maximum, as, due to a

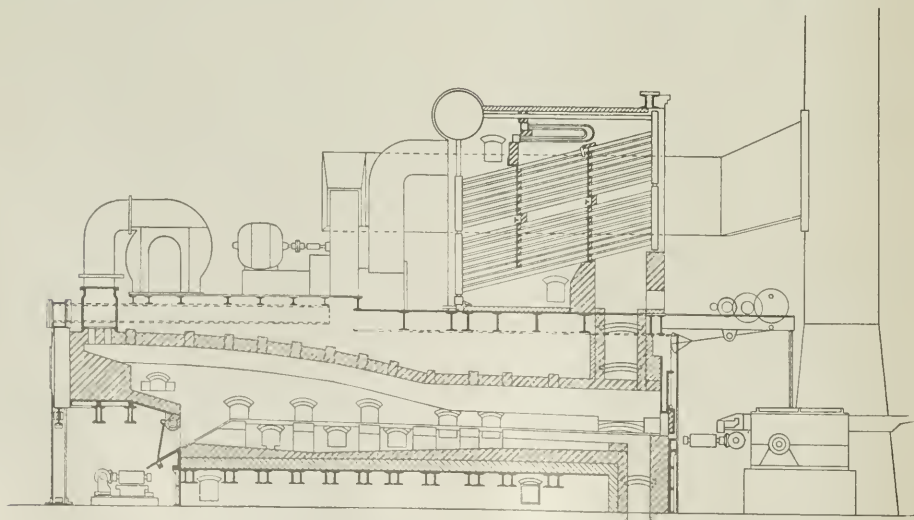


FIG. 7—REHEATING FURNACE AND WASTE-HEAT BOILER ARRANGEMENT

leaky damper, all of the gases from the ovens were not passed through the boiler.

In this plant the boiler was at the end of a range of 22 ovens. The flue was thus rather short, and because of the very low draft requirements of the ovens and natural-draft stack, provided sufficient draft for proper oven operation.

The test at the Frick plant extended over a full week's run of 168 hours. As stated, 44 of the ovens were in operation during the test, the ovens making 48-hour coke and half the number being charged each day with the object of maintaining even gas conditions. Gas weights and temperatures did vary considerably throughout the week. The lowest temperature noted was approximately 1500 deg., while the highest was 2075. The gas weight here corresponds to about the weight that would be passed through the boilers if they were being operated at about rating, coal-fired. The baffles in these boilers were standard, and the draft loss checks the statement made as to rating.

Under such conditions the exit temperatures, which varied during the test from approximately 475 to 550 deg., and averaged, as given, 490 deg., are no lower than might be expected.

The boilers at the Frick plant were located at the middle of a range of 50 ovens, so that the length of flue on either side was not excessive, and the draft requirements could be readily met by a stack 150 ft. high.

In Tests 3 and 4 the interesting features are the low exit-gas temperatures and the high capacities. The exit temperatures of 463 and 477 deg., for ratings of 172 and 192 per cent respectively, are lower by a considerable amount than would be obtained with coal-fired boilers at equal ratings. The design of the boiler to give the high heat-transfer rates noted offers sufficient explanation for these temperatures. In other tests of the Babcock and Wilcox boiler in this series, where the gas weights were such as to give approximately 96 and 128 per cent of rating with entering-gas temperatures of 2013 and 1811 deg., the exit temperatures were 437 and 428 deg., respectively.

At this plant the boilers were at the end of the blocks of 100 ovens and the connecting flues were of considerable length. This explains the necessity for the greater draft suction found at the boiler inlet in this boiler as compared with that in the plants previously described. The draft loss through the boilers is high, but is no more than would be expected when the weight of gas and the area of gas passage are considered. The fan, as stated, was turbine-driven, and a large proportion of the power required for this drive was returned through the exhaust to the feed water.

In this class of work the saving due to the utilization of waste heat is solely in the value of the steam generated. The amount of such saving may be approximated from the boiler capacities given in Table 5. As stated, the gas weight available will be approximately 6.5 lb. per pound of coal coked per hour. On this basis it will be noted from Tests 3 and 4 that 1 hp. was developed for 11.0 and 12.2 lb. of coal coked per hour, respectively, and it would seem conservative to state that with the modern design of waste-heat boiler a horsepower may be developed on the waste gases from 15 lb. of coal coked per hour. At such a return, even granting that beehive ovens will ultimately be replaced with by-product ovens, it would seem that, in numerous plants, an installation of waste-heat boilers would pay for itself many times before such a change could be made. It would be entirely possible, too, in these installations, to design the boilers in such a manner that at the time of replacing the beehive ovens the boilers could be dismantled and reset either for burning coal

or coke breeze, or to be fired with by-product coke-oven gas.

Heating Furnaces

The first boilers for any class of waste-heat work were unquestionably installed with heating furnaces of different descriptions, and the early history of boilers with heating furnaces is in reality the early history of the utilization of waste heat in general. While the writer does not know the actual date of the first installation, it is certain that it was previous to 1872. Before that date such boilers as were used in connection with heating or puddling furnaces were of the cylinder or two-flue design.

An article in the *Iron Age* of April 6, 1893, describes the early installations of water-tube boilers for this class of work and gives some more or less complete results of the performance of a number of these boilers. The first of these installations was made at the plant of the McCullough Iron Works, Wilmington, Del., in 1874, and consisted of two boilers of the Babcock and Wilcox design made up of seven sections of six 16-ft. tubes. Each boiler contained 860 sq. ft. of heating surface and in accordance with the practice of the day were rated on the basis of 11½ sq. ft. per horsepower, or 75 horsepower. To quote the journal mentioned: "These boilers, erected seventeen years ago, have been in constant use ever since and have given entire satisfaction."

TABLE VI—RESULTS OF TESTS OF WASTE-HEAT BOILERS WITH STEEL FURNACES

Test Number	1	2	3 ¹	4 ²	5 ³
Plant	Penn. Bolt & Nut Co., Lebanon, Pa.	Cambria Steel Co., Johnstown, Pa.	Bethlehem Steel Co., So. Bethlehem, Pa.		
Location			Structural Mill Reheating Furnace		
Furnace	Puddling	Single	B. & W.	B. & W.	B. & W.
Boiler	3 Pass. B. & W.	Single Pass B. & W.			
Heating surface, sq. ft.	1196	2,998	5,840	5,840	5,840
Gas weight, lb. per hr.	16,150	87,571	63,932	80,757	80,757
Gas per hour per sq. ft. of h.s., lb.	5.4	15	11	13.8	13.8
Temperatures:					
Gas entering boiler, deg. Fahr.	1,990 ¹	1,745	1,071	1,415	1,415
Gas leaving boiler, deg. Fahr.	542	729 ²	436	401	418
Drop in temp., deg. Fahr.	1,261	1,309	670	1,027	1,027
Draft at boiler damper, in.	0.32	0.23	1.87	1.15	1.50
Draft at boiler inlet, in.	0.19	0.68	0.39	0.34	0.34
Draft loss, in.	0.04	1.19	0.76	0.96	0.96
Horsepower developed.	73.2	152.8	784.1	326	542
Per cent rated capacity.	61	50.9	134	56	93
Approximate transfer rate (R).	1.7	6.1	5.0	5.4	5.4

¹Optical pyrometer.

²Varied at different periods of furnace operation from 604 deg. to 920 deg.

³Tests 3, 4 and 5 on same boiler. No. 3 represents 12-hr. period during which the structural mill was in operation, No. 4 a 12-hr. period with the mill not operating, and No. 5 a continuous run of 104 hr. during which the mill operated 56 hr. and was not in service 48 hr.

A number of boilers similar to these were installed after 1874 in the different iron and steel plants throughout the country. Test 1, Table 6, is representative of the performance of this design of boiler. This test was conducted by J. de Kinder at the plant of the Pennsylvania Bolt and Nut Company, Lebanon, Pa. At this same plant a test on a cylinder boiler in the same service showed exit temperatures considerably in excess of 1000 deg. as compared with 542 deg. for the water-tube boiler, and this temperature difference probably represents the difference in efficiency of the two types of boiler in this class of work.

It is of interest to note that the early waste-heat water-tube boilers with heating furnaces were of the three-pass design. There were, however, a number of factors in heating-furnace work which enabled satisfactory results to be obtained from a design that later was considered more or less impracticable for other classes of waste-heat work. The chief of these was the fact that the draft required at the outlet of the ordinary heating furnace was very low. The boilers were ordinarily set directly over the furnace, and the draft loss between the furnace and boiler was negligible. Furnaces were not driven at the time of the early in-

stallations at a rate that is at all comparable with present-day capacity, and the gas weights to be handled were very low. Further, the boilers were wide and long compared to the height, so that the gas-passage areas were large in comparison to the heating surface. The high exit temperatures ordinarily found enabled a given height of stack to give a greater draft than would the same height under coal-fired conditions.

In 1892 a type of single-pass waste-heat boiler was introduced by The Babcock and Wilcox Company. It is not quite clear why such a design was developed, but the presumption is that with increased furnace capacities the draft loss through a sufficient amount of heating surface in a three-pass design was great enough to interfere with the operation of the furnace. These boilers were of standard sectional Babcock and Wilcox design, but with tubes of 8, 9 and 10 ft. in length. The heating surface required to cool the gases sufficiently was obtained in the height of the boilers, and these were made from 18 to 27 tubes high.

The first boilers of this description were installed in the rolling mill of N. E. Ayre and Company, Portland, Ore., in 1892; one boiler being set over a box-scrap-heating furnace and the second in connection with a small billet-heating furnace. The *Iron Age* article, to which reference has been made, gives some figures on the performance of these boilers, but inasmuch as no temperature or draft measurements are reported, the figures are not included in Table 6. There are included in this table, however, results secured from a boiler of similar design installed in 1901 at the plant of the Cambria Steel Company, Johnstown, Pa. This boiler was of the single-pass type, made up of 10 sections of 27 tubes 10 ft. long and rated at 300 hp.

The results as compared with the earlier three-pass boilers are considerably in favor of that type. Some 7500 hp. of the single-pass design were installed, and in general the results secured were considered commercially satisfactory. Occasional installations of this design of boiler are still made. Because of the construction the boiler was expensive, and probably for this reason was never as popular as the next design of single-pass waste-heat boiler.

This was the Cahall waste-heat boiler, introduced in 1894 by the Aultman and Taylor Machinery Company. This was a single-pass vertical boiler in which the gases were introduced through an annular ring in the mud drum. Baffles were placed in the cone between the tubes with the object of throwing the gases into the tubes, but in view of the temperatures frequently encountered, it is questionable how long such baffles remained in place.

The results secured with this type of boiler were about in line with those of the previous single-pass type, though for a given set of conditions the exit temperatures were probably slightly higher. The Cahall boilers were popular, however, in the iron and steel industry, and over 20,000 hp. were installed. A number of these boilers were fired with blast-furnace gas and were not, therefore, waste-heat boilers.

Other types of boilers were used in this waste-heat work, but the three designs described were by far in the most general use. All of the boilers used were such as to give a minimum draft loss for the amount of gas to be handled, and in this way interfered in no manner with the operation of the primary furnaces.

In 1914 the first waste-heat boilers of strictly modern design and utilizing the theory of high gas velocity were installed for this class of work by the Bethlehem Steel Company. These boilers were of the general design described in connection with open-hearth steel practice, and were made up of 19 sections

of 17 tubes 16 ft. long. They were rated at 584 hp. each, were equipped with superheaters designed to give approximately 75 deg. of superheat, and furnished with motor-driven induced-draft fans. They were set in connection with two 28-in. structural-mill reheating furnaces, the approximate arrangement of furnace, boiler and fan being shown in Fig. 7. An extensive series of tests was run on one of these boilers in the early part of 1915. During these tests the structural mill was operated during certain shifts of 12 hr., while during other shifts the mill was not in service, though the furnace was kept hot. Under these conditions, since the temperatures were considerably lower while the mill was in operation, tests covering a wide range of gas temperatures are available, and the boiler performance under such conditions may be noted. Table 6 gives three of the tests on this boiler. Test 3 of this table represents a 12-hr. period during which the mill was in operation, Test 4 a 12-hr. period during which the mill was out of service, and Test 5 a continuous run of 104 hr., during which the mill was being operated for 56 hr. and was out of service 48 hr.

As in all previous tests, the interesting feature brought out by a comparison of early and modern results is the increase in capacity and decrease in exit temperatures in favor of the modern design. These lower exit temperatures further are secured with gas weights per square foot of heating surface greatly in excess of early practice.

The draft loss through the modern boiler, as indicated in the last three tests of Table 6, is reasonably high, though not nearly as great as found in open-hearth and cement plant waste-heat practice. Since the fan on this boiler was motor-driven, none of the power required for such drive could be reclaimed in the boiler feed. The amount of power required however was small, the maximum for the whole series of tests being about 2 per cent, while the average was 1.55 per cent of the total power generated by the boiler.

In this class of work the only saving through the use of waste-heat boilers is the value of the steam generated. This, however, is certainly a considerable item, and it would appear that there are numerous industrial furnaces that are similar to heating and puddling furnaces and where the temperatures are comparable, with which the installation of waste-heat boilers can show a handsome profit on any investment made.

Miscellaneous

While by far the greater number of waste-heat boilers in service are in the industries outlined above, there are numerous installations in plants of different character. In this miscellaneous class the number of installations in any single industry is small, but it appears advisable to make reference to certain of these, if only to give an idea of the wide and varied field for development in the use of waste heat.

Zinc Furnaces.—The writer has knowledge of over 11,000 hp. of waste-heat boilers set in connection with and utilizing waste gases from zinc furnaces. The temperatures in this class of work are high, being ordinarily in excess of 2000 deg. with certain designs of furnaces and probably averaging well over 1700 deg. with all classes. The draft requirements for the zinc furnace itself are low and, in fact, a number of furnaces are operated with a slight pressure at the exit. Because of these facts, the larger part of the installations with such furnaces has consisted of boilers that are practically standard in design. With

furnaces in which the ore treated is in contact with the gases, fears of the building-up on the tubes of an objectionable deposit led to a modification of boiler design to give more than the customary access to the heating surfaces, in order that all possible might be reached and brushed down should occasion demand. In refining furnaces, where the gases do not come in contact with the metal treated, there is, of course, no danger of such deposit, and standard boiler designs work out satisfactorily.

The results secured from these standard boilers have been entirely satisfactory, and from a commercial standpoint the return in all cases has shown that the expense of the installation has been more than warranted.

One of the first concerns using waste-heat boilers in this class of work for years installed units that essentially were of standard design. As the modern waste-heat boiler was developed, however, this company was persuaded to install such a unit, though the gas velocities were not quite as high as could be desired for the best results. No complete figures of the performance of the modern design as compared to the standard design are available, but the exit gas temperatures from the two designs are indicative of the higher efficiency of the former. One large installation of the modern type of waste-heat boiler has been purchased. These units are not as yet in service, however, and no results are available, but from our knowledge of waste-heat boilers in general there appears to be no reason why the performance should not be in line with known performances in other branches of the work.

Nickel-refining Furnaces.—The International Nickel Company (Orford Copper Works) has in service over 3000 hp. of waste-heat boilers set in connection with nickel-refining furnaces. As in the case of zinc furnaces the temperature of the waste gases is high. While it varies during different portions of the operation, the average is probably in the neighborhood of 1700 deg. when leaving the furnace. The boilers at this plant are of practically standard design, such as used for coal fuel, insofar as baffle arrangement is concerned. No complete test figures are available, but from data at hand the boilers are developing over 90 per cent of their rated capacity with exit gas temperatures of approximately 600 deg. With such a temperature leaving the boiler and a draft resistance through the boiler corresponding to about rating in coal-fired practice, the low draft requirement at the furnace exit is readily met by a 100-ft. stack.

These boilers, as stated, are of practically standard design. As compared with the exit temperature of 600 deg. actually being obtained it would be entirely possible, with the modern type of waste-heat boiler, to reduce this to 450 deg., corresponding to an increase of over 13 per cent in capacity. On the other hand, the design of boiler in use is developing approximately its rated capacity with gases that previous to 1911, the date of the first installation, were wasted. The success of the first units installed was such as to cause this company to duplicate them in later installations, and since these waste-heat boilers have made it possible to shut down a large portion of the coal-fired boiler plant, there was no apparent reason for changing the first design.

In this class of work, as with copper-refining furnaces, the saving due to the reclamation of dust within the setting is an item that compares favorably with the saving, due to the steam generated from the waste gases.

Gas Benches. Several installations of the modern

type of waste-heat boiler in small units have been made in connection with the illuminating-gas benches. The gas temperatures leaving the benches vary somewhat at different periods of the cycle, but where a number of benches are connected to a single boiler—and this is necessary to get a practicable weight of gas—the temperatures entering the boiler are reasonably constant. Complete figures are available of a test run on a modern design of waste-heat boiler in this class of work. The boiler in question has 1330 sq. ft. of heating surface, is equipped with a superheater, and furnished with an induced-draft fan. The boiler is connected to five gas benches, using an average of 211 lb. of coke per hr. per bench. The average temperature of the gases leaving the benches in the test was 1484 deg., while the average temperature entering the boiler was 1225 deg. The boiler test was run at the time the gas benches were first put in operation, and the temperatures, both leaving the benches and entering the boiler, are in all probability somewhat higher than would be the case after normal operating conditions were established.

Under the above conditions, the boiler cooled the gases to approximately 450 deg. (though this figure was undoubtedly affected somewhat by leakage at the damper) and developed 106 h. p., or 79.3 per cent of its rated capacity. The draft loss through the boiler was slightly less than 1 in. While this is not high as compared with other waste-heat work, when it is remembered that the boiler must be at some distance from the furthest bench and hence the connecting flue be of considerable length, and also that approximately 0.75 in. or 1 in. of draft is necessary at the bench outlets, the impracticability of a natural-draft stack, where a boiler is installed in this class of work, is obvious.

In the plant in question the waste-heat boiler generated not only sufficient steam for the requirements of the coal-gas section of the plant, which are low, but a surplus that was almost sufficient for the operation of the water-gas department of the plant.

Oil Stills. At least two installations of the modern type of waste-heat boilers have been made in connection with oil stills, though, aside from the statement to the effect that these boilers are giving satisfactory service, nothing definite on their performance is available.

In this class of work it would appear that the amount of gas available is dependent, to a certain extent, upon the operation of the still, though from reports at hand it would seem safe to figure on approximately 22 to 24 lb. of gas per lb. of oil burned under the stills. The temperature of such gas at a point corresponding to the boiler inlet is approximately 1000 deg., and because a number of stills are connected to a single boiler, this temperature is practically constant.

With the modern design of boiler, as in other waste-heat work, the draft loss is high, and as a draft of approximately 1 in. is required at the stills for proper operation, induced-draft fans are necessary in this class of work.

Embargoes.—From France the exportation of the following articles is no longer permitted: Oxalic acid, albumen, chlorine compounds, carbon chloride, iron or ordinary steel cutting tools, tools and detached parts, machine parts and all other articles in special steel except clock-makers' tools. From Norway copper substitutes and all kinds of rolled and drawn iron wire, condensed milk, cement and bamboo cases may no longer be exported.



FIG. 1—A VIEW OF THE SALT DISTRICT—LUMBER RAFTS ON THE RIVER



FIG. 2—TZULIUTSING—A VIEW FROM THE RIVER

The Production of Salt in Szechuen Province, Western China

By H. K. Richardson

Situated at the extreme western border of China is the isolated mountain province of Szechuen, the largest in area, the most populous and wealthiest province of China. Much has been written of the coal, copper, zinc, antimony and other mineral resources of this wonderful land of nature, but little has been published regarding

the work of the people. The activities of the Szechuenese that have made them famous all over China are: (1) The highly productive salt districts of the province; (2) the production of sugar and sugared fruits; (3) the fine silk, mostly crêpe, sent to all parts of China; (4) the great variety of skins or furs exported, 1,500,000 pieces passing the Chungking custom house per year, and (5) the vast quantity of herbs gathered for medicine, \$1,000,000 worth passing the Chungking custom house for export per year.

The most interesting of all these industries to the chemical engineer is the production of salt. The rela-

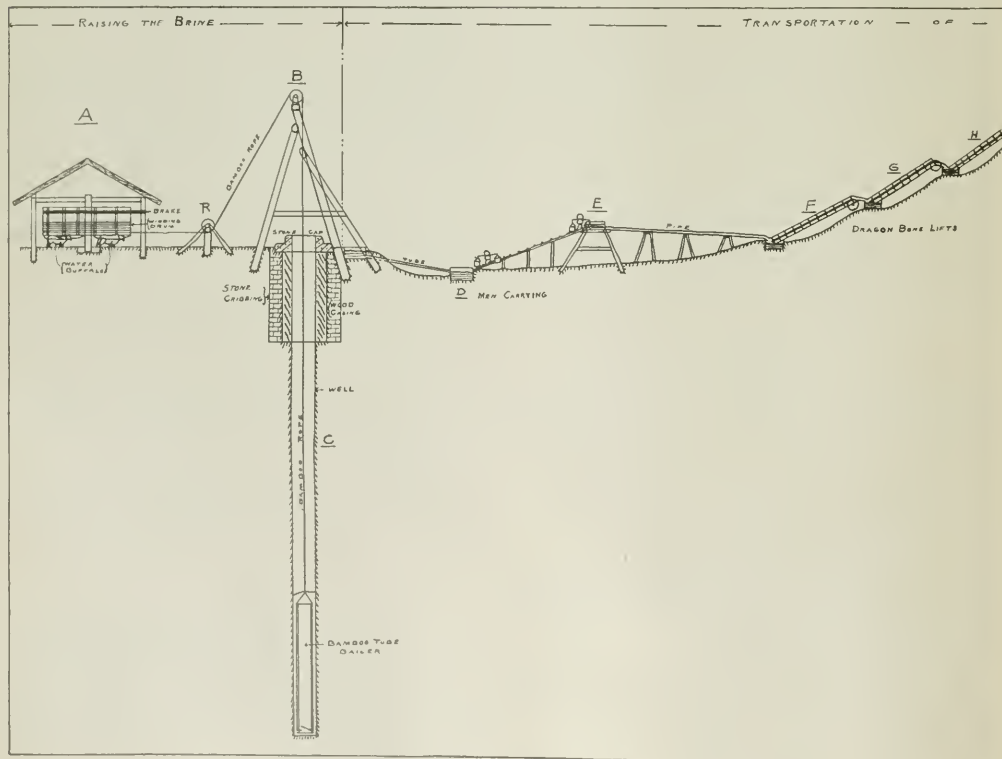


FIG. 4—DIAGRAM SHOWING THE SUCCESSIVE STEPS OF THE CHINESE SALT

tive importance of the salt production of this province to the total production in China is readily seen from the following figures:

1915, total consumption of salt in

China 3,366,000,000 lb.
1915, total salt produced in Szechuen.. 735,000,000 lb.

The Szechuen product is consumed locally and in the provinces of Hupeh, Kueichow, Yunnan, and Kansu, supplying probably 100,000,000, or one-quarter of the population of the republic with this necessity of life.

The salt-producing territory of the province is situated along the river bottoms and hillsides bordering the many streams between longitude 104 deg. and 110 deg. east and latitude 29 deg. and 31.5 deg. north. The whole area covered is about 32,000 square miles.

All of the salt produced is obtained by the evaporation of brine. The brine is obtained from three general types of wells:

1. Salt springs either on the surface or at the bottom of shallow pits. This type is found mostly in the eastern end of the district. The best illustration of this type is the well at Kwei Chow Fu.

2. Wells drilled through clay and soft rock to 1000 ft. This type of well is the most prevalent in the province, and is illustrated by the wells at Tai Ho Chen on the Chengstu-Wanhhsien postroad and Chien Wei Hsien on the Min River near Kiating.

3. Deep wells drilled through hard limestone to 3000 to 4000 ft. All wells of this type are found at Tzuliutsing, in the southwestern corner of the salt well district.

In this article the wells at Tzuliutsing, which are the

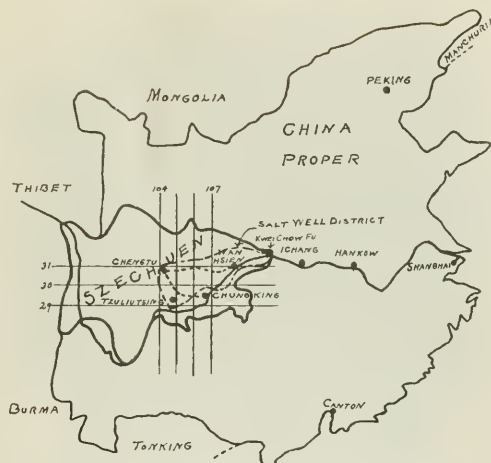


FIG. 3—MAP OF SALT DISTRICT (DOTTED LINES REPRESENT POST ROADS)

largest and most famous wells for salt production in China, will be described, while a future article will deal with the more numerous, smaller, but none the less interesting wells.

Tzuliutsing is a subdistrict made up of a combination of three market towns of the Fu Shun and Yung

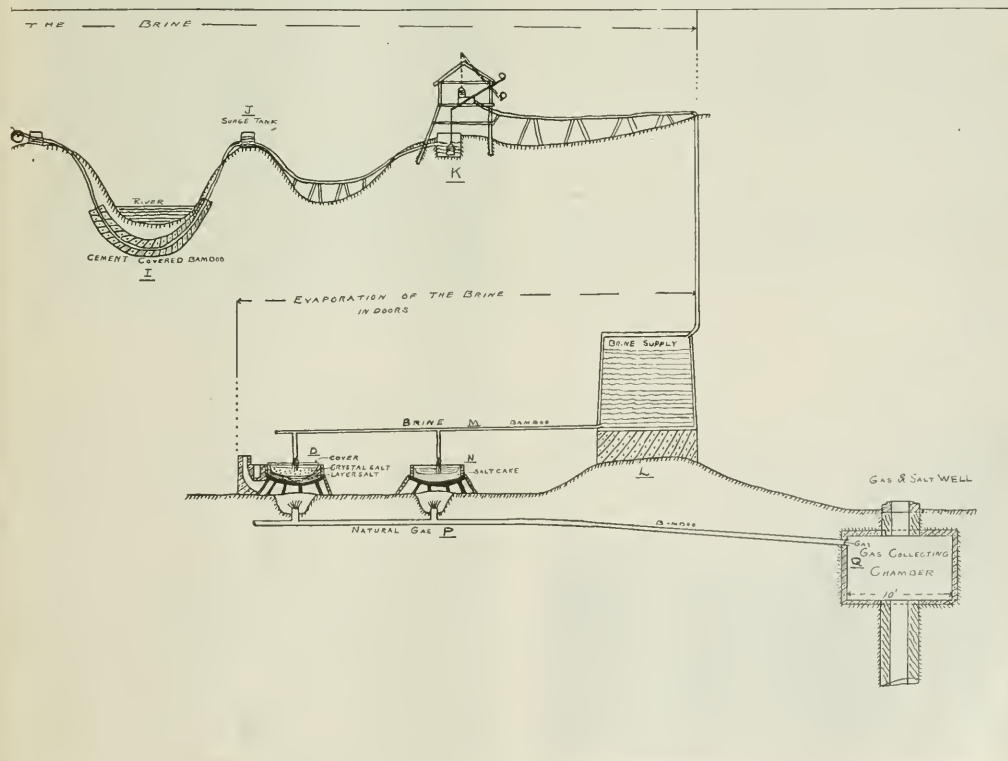




FIG. 5—EMPTYING THE BAMBOO BAILER

Hsien districts of the province of Szechuen. It is 110 miles west of the treaty port of Chungking and 100 miles southeast of Chengtu, the capital of the province (see map, Fig. 3).

The history of these wells is obscure, but they are mentioned in the provincial histories of a thousand years ago. Inquiry as to how the wells were discovered reveals the fact that at the high stage of the river there is a spring on the hillside that bubbles out brine. The district takes its name from this spring, for Tzu Liu Tsing means "Self-Flowing Well."

There are three distinct sections to the district:

In the Deep Well Section the wells are driven through sandstone and are from 2500 to 4000 ft. deep. Natural gas is obtained from some of the wells in this section and used for evaporating purposes. This is the most important section and produces three-quarters of the salt of the district.

In the Medium Well Section the wells are from 1000 to 2000 ft. deep.

In the Shallow Well Section the wells are from 200 to 1000 ft. deep and coal is used to evaporate the brine.

The technique of the process in the three districts is the same except for the evaporating, since practice during more than a thousand years has made the process uniform at the various wells. There are no secret processes, and anyone is free to look around as he pleases.

The operations used to obtain the salt will be consid-

ered under the following heads: Well drilling, process and costs; pumping or drawing the brine, process and costs; transportation of the brine; evaporation of the brine, process and costs; transportation and cost of salt.

Well Drilling

After the location of a new well is decided upon, the first thing is to build a house, derrick and winding drum at that place. The derrick (Fig. 4, B) is made of pine trees. To get the necessary length several trees are spliced together; to get the needed cross-section three trees are bound together with a 1-in. bamboo rope, making a triangular log 20 in. on a side (see Fig.

5). To keep the binding bands tight wooden wedges are driven under the rope.

A pulley 2½ ft. in diameter, made of oak with sides extended to form a groove, is placed on the top cross bar of the derrick; the lifting rope for drills or bailer runs over this pulley, under another larger pulley (5 ft. 6 in. in diameter) held firmly in position by a weighted framework (Fig. 2, R) to the winding drum (Fig. 2, A). The pulley and derrick can well be seen in Fig. 6.

The drum resembles a ferris wheel laid on its side, and is made of wood and bamboo. There are no nails in its construction, all joints are mortise and tenon or tied with bamboo rope. The drum usually has sixteen sides and will wind from 54 to 65 ft. of rope to a turn. It is 7 ft. high and is set 5 ft. up from the ground so as to allow the draught animals to pass under the rope, which winds onto the framework near the bottom.

At the top of the framework is the brake. This is a bamboo tube split on one side and opened out its full width, making a bamboo piece 12 in. wide and the thickness of a bamboo. One end of the brake is firmly secured to one of the shed posts, while the other is tied by a bamboo rope to an adjoining post. To use the brake the brakeman pulls down on the bamboo rope until his whole weight is acting to tighten the band and slow down the drum to the desired speed.

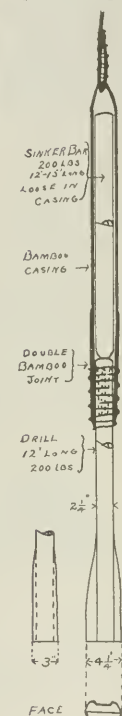


FIG. 7—SALT WELL DRILLER HAND FORGED FROM NATIVE WROUGHT IRON

When lowering the bailer the drum gets up quite a speed, for it makes fifty revolutions in eighty seconds, the time necessary for the bailer to reach the bottom of a 2500-ft. well. The brake must be manipulated carefully, for the bailer must not strike bottom with its force unabated. Fig. 2, A, R, B, and Fig. 6 illustrate the whole apparatus.

The first operation in sinking the well is to quarry out a hole several feet in diameter and 200 ft. Chinese deep. (One foot Chinese equals 1.11 ft. English.) Into the center of this excavation a wooden pipe is placed. This pipe is made from "Song Mu," a wood similar to Georgia pine. The tree is cut into 10-ft. lengths, sawed in halves lengthwise and the heart gouged out to make a 6-in. semicircular hole. The two halves are then bound together, making a wooden pipe 6 in. inside diam. with sides 4 in. thick. These pipes placed end to end in the excavation, are accurately centered and made vertical, then secured in place by stone cribbing.



FIG. 6—WINDING DRUM AND DERRICK

This tube is, in fact, the guide by which the drilling is started, and unless they are carefully placed there will be trouble a-plenty in the future drilling work. More than a thousand years of experience have taught the Chinese that this work must be accurately done to insure a right start, so more care is exercised in this work than is usual in things Chinese. The top of the well is capped with a heavy piece of limestone, cut about 30 in. square and 20 in. thick where the 6-in. hole pierces it. These caps prevent the top of the wooden pipe from being split or abraded by the descending tools.

The drilling is done with a iron spud drill. To make the drill heavier and work better an iron rod is put into the bamboo casing above the drill proper. This serves to give a second blow each time the drill is dropped. (See Fig. 7 for details.) To start drilling the tools are lowered down through the wooden tubes until stone is reached. The tools are suspended by a



FIG. 8—DRILLING A WELL. THE LEVER ARM AND TOP OF DRILLING SET

split bamboo rope from the short end of a lever arm, the rope is adjusted until the lever arm is horizontal with tools resting on bottom.

To drill, the long arm of the lever is depressed by coolies, until the drill is lifted about a foot, when the arm is released and the drills drop. In this work a group of five or six men work on a scaffolding around the long lever arm; to depress the lever they put their right foot on the lever, which is carried down till it reaches the stops, when they step across to the bench opposite, thereby releasing the lever, which flies up, allowing the drills to drop. The movement of the lever is restricted in both directions by guide stops. The men then turn about and return, depressing the lever again. The lever is depressed as high as thirty times a minute, but fifteen to twenty would be nearer the average. Each time the drill raises the man at the well gives the rope a turn. One-half of the men who do the depressing of the lever cross in one direction while the others step in the opposite direction.



FIG. 9—TOOLS TO RECOVER LOST DRILLS, ETC.

The men work ten minutes then rest while the drill rope is being lengthened. Fig. 8 gives a good illustration of the arrangement of the drilling apparatus. The average drilling is 3 ft. in twenty-four hours. To drill an average 2500-ft. well six to twenty years is taken; three to five years only would be needed if the drilling were not interrupted by litigation, lack of capital, loss of tools and various other troubles. The average well takes ten years to become a producer.

The sand and dirt produced by the drilling is removed by the sand pump, a common bamboo tube 20 ft. long. To meet the emergency caused by breakage of rope and loss of tools, the Chinese have invented a wide variety of tools (see Fig. 9). If none of these tools accomplish the work, as a last recourse a new drill is let down and the lost articles slowly churned up. A lost bailer is treated in the same way.

At a well we visited the brine had given out at the 2600 ft. level, so they were drilling further. Since this well is a good average of the district the following data will be of interest:

Depth of drilling	2,600 ft.
Drop of drill per lift	10 3/4 in.
Drill size, Length	12 ft. 10 in.
Diameter	2 1/4 in.
Width of face	4 1/2 in.
Weight	160 catties or 208 lb.
Size of rope	three pieces of split bamboo, each piece 1/4 x 1 in.
Rate of drilling—average	3.33 ft. per twenty-four hours
Number of men	working lever—5; at well—2
Lever arm, Short side	20 in.
Long side	15 ft., center of effort of men at 9 ft.



FIG. 10—TRANSPORTATION OF BRINE COOLIE CARRIAGE



FIG. 11—TRANSPORTATION OF BRINE. FLIGHT OF DRAGON BONE LIFTS

When drilling a well either gas or brine may be struck, but as both are valuable no one complains. A few of the wells yield a little petroleum, but no use is made of it, for it burns with too smokey a flame. No attempt is made to refine it. It is probable that deeper drilling would unlock untold wealth for the province.

A Chinese well operator estimated that the average cost of drilling a well is to

1,000 ft.	3,000 taels or \$2,100 U. S.
2,000 ft.	7,000 taels or 4,900 U. S.
3,000 ft.	25,000 taels or 17,500 U. S.

It is surprising how accurate a Chinese is at arriving at an average. We have found that we could trust figures given as an average, even when the details are wrongly given.

Pumping or Drawing Brine

The brine obtained in the drilling is raised to the surface in bailers. These are bamboo tubes 60 to 110 ft. long and about 4 in. outside diameter. Each tube is made up of several bamboo tubes joined together by tapering ends. To prevent cracking and withstand the pressure, each tube is wrapped, for $\frac{1}{2}$ in. in every 2 in., with hempen twine sunken below the surface. A tube holds about 650 lb. of brine. A bamboo rope made of three braided strands is used to pull the bailer up out of the well. See Fig. 5 for bailer.

The motive power for raising the bailer is of four kinds: (1) Human beings; (2) water buffalo; (3) donkeys; (4) steam engines.

1. Human Beings.—

At some of the smaller wells sixty men and boys will be found slowly toiling to pull the bailer up. This is an old method, and at present rather goes against the grain of the Chinese to use it. The present year is the first time for over six years that it has been in use. The reason is that a very serious epidemic among the water buffalo has made these so scarce that only the wealthy wells can get them. During the epidemic last year one

well lost seventy of its herd of 100 buffalo. Only beggars and orphans are used on this work; they get a place to sleep, one meal a day and 50 cash, or a cent and two-thirds for a day's work.

2. *Water Buffalo*.—The most common motive power is the water buffalo. From five to seven of these big lumbering beasts are hitched to the winding drum. As the bailer nears the top of the well, a rag on the rope is the indicator, and as the load lightens the drivers whip the beasts unmercifully to speed them up. This cruel treatment to a slow plodding animal causes short life. The animals last about four years on the average, when they are traded off for fresh animals. Some of the wells make eighty pulls a day; a pull requires the steady exertion of the buffalo for from ten to twenty minutes, according to the depth of the well. A set of buffalo make two turns of the wheel and then are given eight hours of rest and wallowing in the river. Thus the animal does about thirty minutes' work every eight or nine hours, night and day, as long as it lasts.

3. *Donkeys*.—A few wells use donkeys on the drum. Nine donkeys are used per shift. Ten shifts of animals are provided; each shift is used once and then rests until its next turn. They are a little quicker than the buffalo, but do not seem to be in much favor.

4. *Steam Engines*.—Some ten years ago an English salesman sold a well owner a steam engine to raise the brine. He reckoned five buffalo to be the same as 5 hp., so a 5-hp. engine was delivered. It lacked the needed power and was a flat failure. It has served as a terrible example at the hands of the old conservatives and the told-you-so's, and has discouraged the buying of more machines. About four years ago an engine of Chinese make was tried, and after lots of trouble it worked. Now there are several, mostly of Japanese make, in the territory.

The engines are used in two ways: first, a wire cable is wound around the old winding drum and carried over a pulley on the engine shaft, and the bailer is brought up by its bamboo rope in the old way; second, a half-inch steel cable is connected to the bailer and the cable wound up directly on the winding drum of the engine.

The best example of these engines now in use is a Japanese single-cylinder hoisting drum set with a separate boiler. The engine is a 12-in. stroke with a $7\frac{1}{2}$ -in. cylinder. It is rated at 25 hp., but was only developing



FIG. 12—TRANSPORTATION OF BRINE. BAMBOO PIPE LINES

13 when we saw it. The boiler was 4 by 10 ft., vertical fire tube, and could not supply enough steam for the work. The piping was too small, so there was a big loss in pressure from this source. This engine was making 150 pulls per day to eighty pulls when using buffalo. A pull took eight minutes as against twelve the old way; most of the lost time is due to waiting for the steam pressure to come up. There is a good field here for an enterprising company who will study the requirements of the work and aim to meet them with as cheap a set as possible.

A few years ago a gas engine was tried out, but an explosion in the gas bag due to back fire made it *persona non grata* with the Chinese. Although it did its work fairly well, we saw the dismantled engine being carried out of town last fall.

That we may gain some idea of the size of these wells, the following data, obtained at a well managed and representative well of the district, are given:

Name of well....."Hong Hai Gin"—Red Sea Well
Depth of well.....2,600 ft. Chinese or 2,888 ft. English
Bailer—Bamboo.....3¼ in. O.D. and 2¾ in. I.D.
Length.....105 ft. or 117 ft. English
Contents.....520 catties or 676 lb. of brine
Number of lifts per day.....30
Cost of bailer.....\$12.50 U. S.
Length of use.....one year, one spare on hand
Foot valves.....cost 3 cents, use 15 per month
Time taken per trip.....up, 10 to 12 min.; down, 1½ min.

Bailer rope—Bamboo—1 in. in diameter of 3 strands, each strand made of 30 strips of split bamboo, each strip is 3/16 in. wide by 1/64 in. thick, thus 90 strips per rope. Each length of rope from 24 to 28 ft. long and costs 10 cents. Whole rope costs \$12.00.
A rope lasts 20 days and is replaced 5 lengths per day.

Winding drum—60 ft. circumference, 18 ft. diameter, 6 ft. high.
Buffalos—On drum per trip.....5

Total herd.....80
Original cost each animal.....50 to 80 Taels or \$35 to \$56
Used two, three to ten years, average 4 years, then traded in at about \$15.00.
Feed cost per day.....14 cents each animal

Workers—2 shifts of 12 hours each.
2 men each to cook, repair rope and let out brine.... 6
9 men to feed and carry water for buffalo..... 9
24 men to drive buffalo.....24
3 foremen for men and 1 well boss.....4
7 office help at the well.....7

Help, total.....50

Wages—Ordinary men.....2 to 3,000 cash or \$2.30 a month
Tub men—let out brine.....3 to 4,000 cash or \$2.70 a month
Well boss.....5 to 6,000 cash or \$3.00 a month

Production—Brine strength,
24 oz. of salt per pound of brine or a 15% solution.
Brine lifted per day.....2½ tons, average
Salt in above per day.....4.05 tons, average

Equipment Costs—Derrick, Drum, House, etc.—Taels 4,000 or
\$2,800 U. S.

This well took over six years to drill and has been in active operation for over 100 years. It is the property of a wealthy clan.

From the above data we are enabled to work up a cost sheet of this well; the details follows:



FIG. 14—TRANSPORTATION OF BRINE. LOADING BRINE BOATS

COST OF RAISING BRINE AT THE RED SEA WELL

Production per day.....	\$,100 lb. of salt
Labor Charge.....	Per Day
Feed for buffalo, 80, at \$0.14 each.....	\$11.20
Coolies' wages:	
1 at \$3.00 per month.....	\$3.00
2 at \$2.70 per month.....	5.40
47 at \$2.30 per month.....	108.10

\$116.50/30 3.88

Animals Replacement Charge:

Average use of a buffalo, 4 years, thus, with 80 animals, 20 are replaced per year.

Purchase price.....\$45.00
Traded in price.....15.00 Loss is \$30.00

Thus 20 X \$30.00 is \$600.00/360..... 1.67

Materials:
Repairs to rope, valves, tools, etc..... 1.00

Interest on Investment.....\$17.75

Equipment.....\$2,800
Buffalo.....3,600
Well value estimate.....10,000

\$16,400 at 10% is \$1,640/360 4.56

Total manufacturing cost.....\$22.31
Office incidentals estimate..... 1.69

\$24.00

The manager of the well gave us these details, and also gave us Taels 50 or \$35 as his estimate of the total daily running expenses of this well, including the office upturn.

From these figures it is seen that the cost of raising enough brine to give a pound of salt is 2400 8100, or 0.296 cents per pound or 11.5 cash per catty.

Transportation of Brine

When the bailer reaches the surface of the well the tubeman pushes it aside over a tub, and with an iron hook holds the foot valve up, the brine rushes out into the tub and flows away to the evaporating pans. (See Fig. 5.)

To get the brine to the evaporating pans use is made of gravity wherever possible. To this end bamboo tubes are placed end to end to make a pipe line. These pipe lines can be seen going up hills, through houses and sometimes under the river. It is hard to dig a foundation without striking either an active or an abandoned pipe line. All pipe lines lead to natural gas wells. When it is necessary to raise the brine beyond the level of its source the Chinese made use of several ingenious schemes.

Coolie Carriage.—One of the simplest of these schemes is to elevate a tank upon a platform and have coolies carry the brine up to it in buckets and empty them into the tank. (See Fig. 2, D. E. and Fig. 9.)

Dragon Bone Lift.—A very common type of lift for use on the hillsides is the dragon bone lift. This lift is in use by the farmers for irrigating the fields and lifting water to moderate heights. This machine resembles a wooden chain pump laid on its side. It

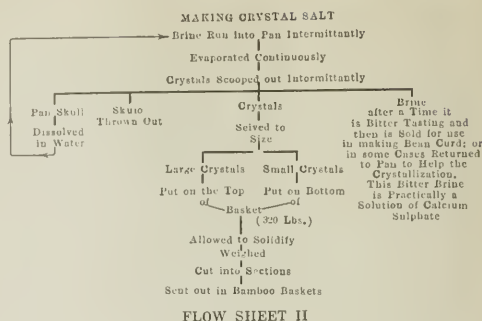


FIG. 13—TRANSPORTATION OF BRINE. HORSE-DRIVEN WINDLASS AND BUCKET LIFTS

consists of a wooden jointed chain carrying thin oblong wooden vanes attached at right angles to the chain; the chain works in a long box open on the top and at both ends. The box is about 16 ft. long and has a cross-section of 6 in. deep by 10 in. wide. The chain with its vanes passes over a notched wheel at either end of the box. The upper wheel is turned either by a hand crank, by men working treadmill fashion, or by a gear and animals. The lower end of the box is placed in the brine and the traveling vanes entrap the liquid, which is carried up the box and discharged over the upper end. When the hill is high, cascades of five or more are needed. In this case each one is the feeder to the one which is above. (See Fig. 2, F. G. H. and Figs. 11 and 15.)

Windlass Lifts.—Sometimes an endless chain of buckets is arranged to lift from one level to another; sometimes it is one bucket only making an intermittent process. These are worked by hand crank, pulling or by horses through gears. (See Fig. 13.)

Compensated Bucket Lift.—From the long end of a lever a bucket is hung by a bamboo rope, while to the short end a stone that nearly compensates the weight of a full bucket of brine is tied. The fulcrum of the lever is on the top of a post and the rope passes down



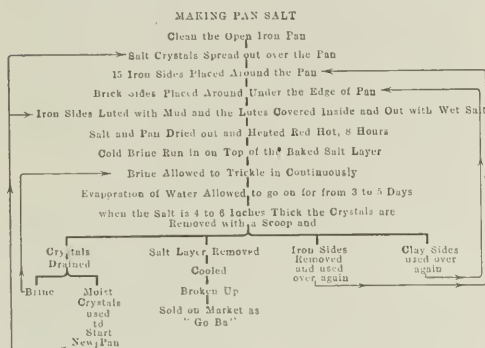
the unloading. (See Figs. 14 and 15.) The longest pipe line is about 7 miles.

Evaporation of Brine

The brine from the various wells is conducted to the vicinity of the gas wells and there evaporated in open pans over gas flames. The burners are rented to the owners of the brine, who furnish the workers and all the apparatus needed in the evaporating work. Two kinds of salt are made, the cake or pan salt and the crystallized.

The outlines of the process for making pan salt is given in Flowsheet I. The process for the production of the salt crystals is a little different. In the first place the pans are more carefully prepared for they are more permanent, after which the scheme given in Flowsheet II is used.

The iron pans used for the evaporating are shallow segments of a sphere 62 in. in diameter and 4 in. deep. The iron is 3 in. thick at the center and $\frac{1}{2}$ in. thick at the edges. They are made of native cast iron and weigh from 1400 to 1600 lb. They cost 43 taels, or \$30.10. When used for making pan salt they will last thirty or forty heats before cracking, and when repaired are good for as many more. As the usual heat is four days, they last nine months. The discarded pans are traded in for part payment for new pans. The fifteen iron side plates are in fact a detachable side rim 6 in. wide, and are used so that the salt cake can be easily removed. These fifteen sides cost about \$9 a set and weigh 23 lb. each. In one evaporator house we visited there were 101 pans all making the salt cake. Fig. 16 shows a set of the pans and Fig. 2, N and O show



through the floor of the platform built over the tank. To lift the brine the bucket rope is pulled down until the bucket is filled in the lower tank, when the rope is pulled up and the bucket dumped at the higher level, 15 ft. above the tank. This scheme is also used to irrigate vegetable gardens from wells. (See Fig. 2, K, and in background of Fig. 10.)

Surge Tanks.—When the pipe lines are long and pass over wide valleys the pressure on the pipes is high, so a surge tank is placed at an elevation in the valley, slowing up the speed of the brine and easing up on the pressure. It is also found on the top of a hill where suction might cause the collapse of a tube. (See Fig. 2, J, and 12.)

All the pipes are bound with split bamboo, over a mixture of chalk and China wood oil, so that they are fairly satisfactory. They leak a little and it is no uncommon sight to see beggars digging up the salt-carrying earth under a pipe line and leaching it to get the salt. The pipe lines are rarely tampered with, for it is a criminal offense heavily punishable to disturb them.

In the part of the district where the brine has to be carried so far that the Chinese feel that a pipe line is too long, the brine is run into scows and poled up the river and unloaded. The dragon bone lift is used for



FIG. 15—TRANSPORTATION OF BRINE. UNLOADING BRINE BOATS



FIG. 16—EVAPORATION OF BRINE. SALT CAKE PANS

the construction for pan and crystal evaporation respectively.

When pan salt is made there is no attempt to get much draft under the pan—the leaks are plenty. The pan is set up on 2 x 2 x 10-in. stone legs and thin brick laid up around the edge to prevent the wind from blowing the gas flames. When making crystal salt the pan is set more permanently so a draft tube is provided at the back, while openings in the brick at the front provide for the needed regulation. (See Fig. 2, O.)

Gas Wells

The gas wells were originally driven for brine, but as they give off the gas, they are almost wholly used for the gas. To collect the gas a chamber of cement 7 ft. high and 10 ft. long is made around the well just below the ground and the wooden pipe cut out of this section. The gas arising collects in this chamber, the well is not capped as has been said, and no gas is smelled at the top, for the burners are situated 20 ft. higher than the level of the gas chamber and their burning sucks all the gas up the tubes. The gas pipes are 3-in. (inside diameter) bamboo tubes leading out of the top of the box. One well we were visiting served 200 burners, which were burning about 20,000 cu. ft. of gas per hour. When the brine rises and cuts off the gas supply a bailer is put down and the brine removed. This gives too much gas for a while and the pressure is relieved by lighting a big auxiliary torch, which serves as a safety valve. Fig. 16 shows such an auxiliary torch.



FIG. 17—NATURAL GAS WELLS—SURPLUS RELIEF BURNERS

The burners are made from bamboo tubes coated with a 2-in. layer of Chinese cement. Chinese cement is made from broken tile hammered fine, lime and sand or mud well mixed and hammered into place. Fig. 17 shows these burners, while Fig. 2, P and Q show the gas system.

The cost of evaporating is hard to calculate, but Sir A. Hosie estimates that it was 2 to 4 cash in 1884. (Report on province of Ssuch'uen, page 98.) The cost at the present time cannot be far from 4½ cash per gin or 0.15 cents per pound of salt.

If we add this value to the cost of raising the brine we have the following as the total cost of producing salt:

Raising brine.....	11.5 cash per gin or 0.236 cents per pound
Evaporation	4.5 cash per gin or 0.150 cents per pound
	16.0 cash per gin or 0.446 cents per pound

Under the present uniform tax administered by the Salt Gabelle a hundred gin or 133 1/3 lb. of salt pay a tax of \$2.50 silver. At an average of exchange of 1,500 cash per silver dollar this is 37.5 cash per gin or 0.967 cents per pound. Thus the salt at the place of pro-



FIG. 18—INSPECTING AND WEIGHING CAKES OF SALT CRYSTALS. NOTE GOVERNMENT STAMP ON THE CAKE IN THE SCALE. NOTE OVERLAND COOLIE CARRIAGE OF THE SALT TO EAST AND WEST

duction, duty paid, costs 53.5 cash per gin or 1.413 cents per pound. Fig. 18 shows the weighing of crystal salt at the tax office and its preparation for transport.

Road transport by coolies costs 12 cents per 120 lb. per day of 25 miles, or one-tenth of a cent per pound per 25 miles. Chengtu the capital is 150 miles from the salt wells, and salt retails there for 80 cash a gin or 2 2/3 cents a pound. As the salt well gin has 18 oz. and the retail gin 16 oz., there is some chance for profit. The retail price of salt is fixed by the government for each locality.

It is said by the Chinese that there are 10,000 wells in the district. Of these 5000 are active and 500 in process of drilling, while the rest are abandoned or in litigation. In 1904 Tzuliutsing produced 183,000 of the 279,433 tons of salt credited to Szechuen by the salt office. The 1913 production for Szechuen is given as 367,246 tons, and if Tzuliutsing produced the same proportion as in 1904, the 1913 production would have been 244,830 tons.

Most of the wells are not large producers, probably not over 10 per cent of the active wells will produce as much as the representative "Red Sea Well." If the remaining 90 per cent had only a production of half a

ton the average of the whole lot of wells would be only three-quarters of a ton per day, thus the daily production of the district, 677 tons, would come from 900 wells, and the remainder of the 5000 wells would be producing less than nothing. It is thus evident that either the number of the wells is wrongly estimated by the Chinese or that a fewer number are active.

Some one discovered that a few of the wells were pumping from the same pocket, so when the wells ran dry, water was run down into the deepest well, a 2500-foot well, and now twenty-three wells in an area of a square mile can be pumped. At present about 150 gal. of water a minute is run into this well for half a day at a time. Thirteen of the wells can pump continuously from the water thus supplied. In order that the owners of the pumping wells can be sure that they are getting what they pay for, rice hulls are fed in with the water into the big well.

The stopping of leaks in the well shows the ingenuity of the Chinese. When a fresh water leak threatens to impair the usefulness of the well, its location is ascertained, then a bunch of coarse grass is rammed down below the position of the leak. On to this grass a mixture of mud, lime and China wood oil is poured; this is allowed to harden to a cement. The drill is then put down and a hole drilled through the cement, the grass removed and the leak is effectually stopped. This is the same method which has been lately advised to be used in stopping the waste of natural gas from oil wells. One who thinks that all progress in technical matters is associated with the Anglo-Saxon race, will be very much surprised at the development reached in this district some thousand years ago. The trip is well worth its cost.

BIBLIOGRAPHY. There are three descriptions that have been given of this territory, 1904; Sir A. Hosie in "Report on the Province of Szechuen," British blue book, China 5 (1904), 1909; Mr. R. O. Jolliffe in "Our Share in China," page 113, etc., and Messrs. Head in "Mining and Scientific Press," Oct. 24, 1914, this is a translation of a French paper.

Electrolytic Behavior of Tungsten*

By Walter E. Koerner

The electrolytic behavior of tungsten has not been extensively investigated. Almost all of the earlier investigators have worked on the electrolytic deposition of metallic tungsten, their object being probably to produce tungsten in a tangible form by a relatively simple method.

The first researches upon the electrolytic reduction of tungsten were made from solutions of fused baths of tungstates. Zettnow¹, in an article published in 1867, describes a black amorphous powder of metallic tungsten which he obtained, along with sodium bronze, by the electrolysis of molten sodium tungstate. Hallopeau², obtained by the electrolysis of molten lithium paratungstate, with platinum electrodes, crystals of metallic tungsten. Stavenhagen³, however, under the same conditions, obtained no metallic tungsten, but only lithium tungsten bronze. Scheibler⁴ and Knorre⁵ describe in their papers a large number of tungsten bronzes which they obtained by the electrolysis of molten tungstates.

Martin⁶ obtained impure metallic tungsten by the electrolysis of tungstic acid dissolved in molten cryolite, analogous to the method of preparing metallic aluminium. The electrolysis of molten baths of halogen or oxyhalogen compounds of tungsten is not feasible as these compounds are not very good conductors.

Little is known about the electrolysis of aqueous and non-aqueous solutions of tungstates. Smith⁷ observed that no effect is produced by the electrolysis of neutral solutions of tungstates, but that in acid solutions a blue color and a blue precipitate (presumably W_2O_5) is produced. The blue compound changes to brown as the current is allowed to run for some time. When the compound is exposed to the air after electrolysis, the brown changes back to blue.

The author does not agree entirely with Smith. He not only obtained the blue and brown compounds described by Smith, by the electrolysis of sodium tungstate acidified with H_2SO_4 , but he also obtained a blue solution and a blue precipitate which turned to brown by the electrolysis of sodium tungstate in a neutral solution. The conditions, however, were somewhat different. Smith used platinum electrodes, while the author used tungsten electrodes.

Leiser⁸ electrolyzed an acid solution of sodium tungstate between a nickel anode and a platinum cathode, and obtained a blue precipitate which when analyzed was found to be W_2O_5 . With a lead cathode he obtained a brown deposit which probably was WO_3 .

Rosenheim⁹ electrolyzed a solution of H_2WO_4 in an alcoholic solution of HCl (gas). H_2WO_4 dissolves in this solution to the extent of 9.8 per cent H_2WO_4 . He used graphite as anode material. With a platinum cathode the reduction proceeded only as far as penta-valent tungsten (W^{V}). With mercury or cadmium cathodes, the reduction varied with the current density, while with zinc cathodes, the reduction proceeds to tetra valent tungsten (W^{IV}). Rosenheim obtained a series of oxides of tungsten varying in valence from five to two. He obtained no metallic tungsten.

Up to this date, 1909, no satisfactory method had been developed for the electrolytic deposition of tungsten and no metallic tungsten had been obtained.

In June, 1910, a patent¹⁰ was issued in Germany for the electrolytic deposition of metallic tungsten from an aqueous or organic solution of pertungstic acid, H_2WO_6 , or one of its salts.

In the same month of the same year, a second patent¹¹ was issued to the Wolfram-Lampen A.G. for the electrolytic deposition of tungsten from organic solutions of WCl_6 .

Fischer¹² tried to deposit metallic tungsten from solutions of WCl_6 in absolute ethyl alcohol saturated with HCl (gas) and from solutions of WCl_6 in glycerine. With the latter the concentration of the dissolved WCl_6 was too small for practical observations. Fischer used carbon as anode and platinum as cathode in his work. With a low concentration of WCl_6 (3 gm/150 c.c. of alcohol), he obtained a green solution, the green color being due to a reduction to penta valent tungsten. He¹³ found this green color to be due to a triethoxyl substitution product of tungsten pentachloride, $WCl_5(OCH_3)_3$.

With a higher concentration (22 grams of WCl_6 per 120 c.c. of alcohol) he obtained, on the cathode, a black precipitate which could not be strictly called tungsten metal. He decided that it was WO_3 .

Fischer tried also to obtain tungsten by the method described by other German patents¹⁴ but without success. He obtained by the electrolysis of pertungstic acid, a blue-black precipitate, which when analyzed showed 92.33 per cent tungsten. This corresponds to WO_3 .

It seems, in going over the literature, that although some of the earlier investigators thought that they had produced metallic tungsten by electrolysis, in nearly every case the precipitate obtained was some tungsten

*A paper presented at the New York Meeting of the American Electrochemical Society on September 8, 1916.

¹ See p. 47 for all references.

compound, principally WO and perhaps a lower oxide. Fischer tried to verify the claims made by the German patents, but he obtained no pure metal.

The work on the electrolytic behavior of tungsten which the author here presents in a preliminary report, was divided into four sub-heads.

1. Single potentials E. P. of tungsten:
 - A. E.P. of tungsten in various electrolytes.
 - B. E.P. of tungsten in saturated solutions of tungsten hydroxide in various electrolytes, bearing on the solubility of tungsten oxide.
2. The anodic behavior of tungsten and passivity:
 - A. In acids, and in neutral salt solutions in water.
 - B. In acids, and in neutral salt solutions in organic solvents.
 - C. In inorganic and organic alkalies with a bearing on the electrolytic recovery of tungsten.
3. A. The use of tungsten in a voltaic cell.
B. The use of tungsten in a standard cell.
C. The use of tungsten in a storage cell.
4. The author has reserved all observations made on the electrolytic deposition of tungsten for future publication.

Single Potentials of Tungsten

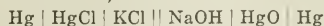
The single potential measurements were made in order to obtain some light on the relative solubility of tungsten in solutions of various electrolytes.

Insoluble electrodes give single potentials of the positive and negative ions in solution. In a 1/1 n. NaOH solution we should get, if the anode were insoluble, the value of the oxygen electrode, 1.47 V (H = O). The single potential for tungsten in 1/1 n. NaOH solution is -0.316 V (H = O), a value very much smaller than the oxygen potential. It follows, then, that the tungsten anode goes into solution in NaOH and ionizes. The rate of solution varies with the solvent used.

Three half cells were used as auxiliary electrodes in measuring the single potentials. The first, the normal KCl-calomel half cell, was used with acid and salt solutions. The second, a half cell made from Hg, red HgO and 1/1 n NaOH was used with alkali solutions. The third, a half cell made from Ag, Ag₂O and 1/1 n NaOH was used as a check on the other two cells.

The 1/1 n KCl-calomel electrode was made according to standard specifications.¹⁸ The single potential of this electrode was taken as +0.56 volts. The potential of the second cell, made with the same construction as the first, but having HgO substituted for HgCl, and 1/1 n NaOH substituted for KCl, was taken as +0.445 volt¹⁹. The third cell, made from Ag, Ag₂O and 1/1 n NaOH was taken as +0.655 volt²⁰. The cells were checked up against each other and found to agree within amounts not greater than those allowed for experimental error.

In the combination,



the emf. obtained was 0.1588 volt with the mercury in the calomel, positive. If the single potential of the calomel electrode is +0.56 and that of the mercury oxide electrode is +0.445 V., the emf. produced by the combination, neglecting the liquid potential KCl | NaOH should be +0.115 volt. Since we get an emf. of 0.1588 volt, we conclude that the liquid potential KCl | NaOH is +0.0438 volt.

Similarly with the combination,



(the silver being positive) we get an emf. of +0.0488 volt. The value of the liquid potential KCl | NaOH is calculated to be in this case +0.0462 volt.

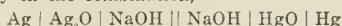
$$+0.655 + x + (-0.56) = 0.0488$$

$$x = -0.0462$$

$$x = \text{NaOH} | \text{KCl} = -0.0462$$

then $-x = \text{KCl} | \text{NaOH} = +0.0462$.

Finally in the combination,



with silver positive, the emf. obtained was 0.209 volt. This checks up with 0.210 volt = [+0.655 + (-0.445)].

The tungsten electrodes used in these measurements were 75 mm. long and 3.2 mm. in diameter. They were made from a high-grade tungstic acid which was reduced to tungsten metal by hydrogen. The metal powder was pressed into a rod at a high pressure and melted electrically in hydrogen. After cooling in the same gas, the rod was hot swaged to size, cut in half, and two electrodes of the same composition obtained.

Before making the choice of this form of tungsten metal, we made several single potential measurements with different kinds of so-called tungsten metal, made by different processes. It was found that the potential of these various metals in 1/1 n NaOH varied within wide limits. A black finely divided metal powder had a single potential of -0.704 volt (H = O), while gray compact melted rod had a single potential (E.P.) of -0.316 volt (H = O). See Table I.

Upon closer and further observations we concluded that the finely divided black metal contained a lower form of oxide, either as a mechanical mixture, or adsorbed to, and covering the metal particles. The high E.P. in this case is not the W | NaOH potential, but the E.P. of W₂O₃ | NaOH. Tungsten oxides are more soluble in NaOH than W and have higher E.P.'s in NaOH than tungsten.

Following is a table showing the emf.'s as measured with the Hg | HgO | NaOH electrode, of various forms of tungsten metal. The E.P.'s are expressed in terms of calomel = O, calomel = +0.56 and hydrogen = O.

TABLE I

1	2	3	4	5
Form of Metal	EMF.	E.P. Cal=0	E.P. H=0	E.P. Cal=+0.56
	Volts	Volts	Volts	Volts
Black powder	+0.872	-0.987	-0.704	-0.427
Gray powder	+0.776	-0.891	-0.608	-0.331
At. Wt. powder	+0.657	-0.882	-0.499	-0.222
Rod No. 1	+0.873	-0.988	-0.405	-0.128
Rod No. 2	+0.561	-0.676	-0.393	-0.116
Rod No. 3	+0.494	-0.609	-0.326	-0.049
At. Wt. rod	+0.484	-0.599	-0.316	-0.039

Column 2 in Table I gives the emf. values as actually measured. They may also be taken as E.P.'s of NaOH | W when the value of the auxiliary electrode is taken as zero. The E. P.'s of W | NaOH would be the same values numerically, but opposite in sign.

It was suggested, at the International Congress of Berlin²¹, that in all cases the directly measured values be given and that the 1/1 n KCl calomel or the Nernst hydrogen electrodes be employed as auxiliary electrodes and taken as zero. These direct measurements may be taken as the E.P.'s of the combinations referred to the calomel or hydrogen electrodes as zero. (Cal = O) (H = O). Since we used the HgO half cell (already described) as the auxiliary electrode, it is necessary to calculate to the calomel values. The relation of calomel to mercury oxide is,

$$\text{E.P. Cal} = \text{HgO} + 0.115 \text{ volt.}$$

It follows that in order to change the HgO values to calomel values, it is only necessary to add 0.115 volt to the emf. readings and change the signs to reduce these to W | NaOH. These E. P.'s are shown in column 3.

A relation also exists between the E.P. of the hydrogen electrode and that of the calomel electrode. This relation²² is expressed by

$$\text{EP}_H = \text{EP}_{cal} + 0.283 \text{ volt.}$$

Column 4 gives the E.P.'s of W | NaOH compared to H = O.

Column 5 gives the values in terms of Cal = +0.56 volt.

The emf.s' given in Table I and the following tables were obtained by means of a Wolff potentiometer connected, with a standard Weston element, to a small storage cell to furnish current and a D'Arsonval galvanometer. After compensating the standard Weston element and the storage cell, the potentiometer was adjusted to zero swing on the galvanometer. The emf. was read directly from the potentiometer.

The customary precautions were taken in connecting up the cells to prevent the different electrolytes from mixing. Glass U tubes 80 mm. long and 2 mm. bore through which clean cotton cord was passed, served to connect one electrolyte with another. In some cases, a cup containing the same electrolyte as the one in which the tungsten was immersed, was interposed between the latter and the cup containing the second electrolyte. This was to further reduce the contamination of the first electrolyte with the second.

Table II gives the results obtained with W in the various electrolytes used.

In Table II, column 1 gives the 1/1 n acid solutions in which the tungsten rod was immersed. Column 2 gives the emf.s' measured with the calomel electrode as an auxiliary electrode. Column 3 shows the calculated

TABLE IV—HALOGEN SALTS 1/1 N—MEASURED WITH THE AUXILIARY ELECTRODE H₂ HgCl/KCl = +0.56

1	2	3	4	5	6	7
Salt	E.M.F.	E.P. W/sol Cal = +0.56	E.P. KCl/ sol	E.P. W/sol Corrected Cal = +0.56	E.P. W/sol Cal = 0	E.P. W/sol H = 0
	Volts	Volts	Volts	Volts	Volts	Volts
KF	+0.235	+0.325	-0.0037	+0.2213	+0.239	+0.522
KCl	+0.280	+0.280	0.000	+0.280	+0.280	+0.563
KBr	+0.306	+0.264	+0.0004	+0.264	+0.306	+0.539
KI	+0.450	+0.11	+0.0002	+0.11002	+0.450	+0.733

TABLE V—K SALTS OF ACIDS OF TABLE II—MEASURED WITH THE AUXILIARY ELECTRODE H₂ HgCl/KCl = +0.56 V.

1	2	3	4	5	6	7
Salt	E.M.F.	E.P. W/sol Cal = +0.56	E.P. KCl/ sol	E.P. W/sol Corrected Cal = +0.56	E.P. W/sol Cal = 0	E.P. W/sol H = 0
	Volts	Volts	Volts	Volts	Volts	Volts
K ₂ SO ₄	+0.430	+0.130	-0.013	+0.121	+0.416	+0.719
KCl	+0.280	+0.280	0.000	+0.280	+0.280	+0.563
KNO ₃	+0.017	+0.593	-0.0037	+0.513	+0.017	+0.390

E.P.'s of W | sol compared to calomel = +0.56 volt, disregarding liquid potential KCl | acid sol. Column 4 gives the E.P.'s KCl | acid sol. calculated from Planck's

formula $\left[EP = 1.99 \times 10^{-4} T \log \left(\frac{U_1 + V_2}{U_2 + V_1} \right) \right]$. Column

5 shows the E.P.'s W | sol. corrected for liquid potential KCl | acid sol. (calomel = +0.56 volt). Column 6 gives the E.P.'s for W | sol. compared to calomel = 0 not corrected for liquid potentials, while column 7 gives the E.P.'s for W | sol. cal = 0 corrected for E.P.'s KCl | acid sol. Column 8 gives the E.P.'s for W | sol. compared to H = O.

Table III gives the same results for bases as Table II gives for acid. In this case the auxiliary electrode Hg | HgO | NaOH = +0.445 volt was used. Column 5 gives the E.P. W | sol. compared to HgO = +0.445. These values are identical to E.P. W | sol. compared to cal. = +0.56. From these figures the E.P. W | sol. values compared to cal. = 0 are obtained and given in column 6. The E.P.'s W | sol. H = 0 are shown in column 7.

Tables III-b and III-c are practically the same except that in the former case we used the silver oxide electrode, while in the latter we used the calomel electrode. Table IV gives the results obtained with 1/1 n solution of the halogen salts of K, and table V, the results obtained with K salts of the acids shown in Table II.

It is seen from Table II that the E.P. W | 1/1 n acid sol. varies with the acid used, and that it is highest with HNO₃ and lowest with H₂SO₄. Tables III-a, III-b, and III-c show that with KOH and NaOH the E.P.'s are practically the same, while with NH₄OH the E.P. is lower numerically and higher algebraically than those of NaOH or KOH. The E.P. of W | KCN is much higher numerically (and lower algebraically) than any of the others. Tables IV and V show the E.P. for W | sol. in the various salts.

The potential of tungsten in 1/1 n HNO₃ may be compared to the potential of copper in 1/1 n (ion concentration) CuCl₂ solution. The E.P. of Cu | CuCl₂ is -0.329 volt (H = O)², while that of As | AsCl₃ is +0.293 volt (H = O).

The potential of W in the alkalis may be compared in the same way, that of W in KCN being higher than that of iron but lower than that of nickel; the potential of W in NaOH, KOH and NH₄OH being higher than that of thallium, but lower than that of tin. In like manner the potentials of W in the halogen and other

TABLE II—1/1 N ACIDS—MEASURED WITH AUXILIARY ELECTRODE Hg₂ HgCl/KCl = +0.56 V

1	2	3	4	5	6	7
1/1 n Acid	E.M.F.	E.P. W/sol Cal = +0.56 V.	E.P. KCl/ sol	E.P. W/sol Corrected Cal = +0.56	E.P. W/sol Cal = 0	E.P. W/sol H = 0
	Volts	Volts	Volts	Volts	Volts	Volts
H ₂ SO ₄	+0.060	+0.590	-0.030	+0.470	-0.060	+0.193
HCl	+0.028	+0.562	-0.029	+0.533	+0.028	+0.236
HNO ₃	-0.057	+0.617	-0.029	+0.588	+0.057	+0.311

TABLE IIIA—1/1 N BASES—MEASURED WITH AUXILIARY ELECTRODE Hg₂ HgO | NaOH = +0.445

1	2	3	4	5	6	7
1/1 n Base	E.M.F.	E.P. W/sol HgO sol. Cal = +0.445	E.P. HgO sol.	E.P. W/sol Corrected HgO = +0.445	E.P. W/sol Cal = 0	E.P. W/sol H = 0
	Volts	Volts	Volts	Volts	Volts	Volts
KOH	+0.481	+0.036	-0.002	-0.018	-0.598	-0.315
NaOH	+0.454	-0.039	0	-0.039	-0.599	-0.316
NH ₄ OH	+0.406	-0.039	0	+0.039	-0.521	-0.238
KCN	+0.715	-0.370	0	-0.370	-0.930	-0.647

TABLE IIIB—1/1 N BASES—MEASURED WITH THE AUXILIARY ELECTRODE Ag | Ag₂O | NaOH = +0.655

1	2	3	4	5	6	7
1/1 n Base	E.M.F.	E.P. W/sol HgO sol. Cal = +0.445	E.P. HgO sol.	E.P. W/sol Corrected HgO = +0.445	E.P. W/sol Cal = 0	E.P. W/sol H = 0
	Volts	Volts	Volts	Volts	Volts	Volts
KOH	+0.690	-0.045	-0.002	-0.037	-0.597	-0.314
NaOH	+0.634	-0.039	0	-0.039	-0.599	-0.316
NH ₄ OH	+0.615	-0.040	0	+0.040	-0.550	-0.237
KCN	+1.034	-0.379	0	-0.379	-0.930	-0.656

TABLE IIIC—1/1 N BASES—MEASURED WITH THE AUXILIARY ELECTRODE H₂ HgCl/KCl = +0.56

1	2	3	4	5	6	7
1/1 n Base	E.M.F.	E.P. W/sol Cal = +0.56	E.P. KCl/NaOH	E.P. W/sol Corrected Cal = +0.56	E.P. W/sol Cal = 0	E.P. W/sol H = 0
	Volts	Volts	Volts	Volts	Volts	Volts
NaOH	+0.648	-0.038	-0.048	-0.010	-0.630	-0.347

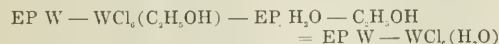
TABLE VI

1	2 E.P. W/sol H=0	3 E.P. H=0 Le Blanc	4
	Volts	Volts	
KCN	-0.647	-0.660	Fe
		-0.610	Tl
		-0.322	
NaOH...	-0.316		
KOH	-0.315		
NH ₄ OH	-0.238		
		-0.192	Sa
		-0.148	Pb
		0	H
H ₂ SO ₄	+0.193		
HCl....	+0.256		
		+0.293	As
KNO ₃	+0.300		
HNO ₃	+0.311		
		+0.329	Cu
		+0.466	Sb
KF	+0.522		
KCl	+0.563		
KBr	+0.580		
K ₂ SO ₄	+0.719		
KI	+0.733		
		+0.750	Hg

salts can be compared with the potentials of other metals.

We have arranged a relative potential table in order of increasing E.P. algebraically from the lowest algebraic value to the highest algebraic value. See Table VI. In column 2 are given the E.P.'s of W | sol. calculated from the measurements taken. Column 3 gives the E.P.'s for Fe, Ni, Tl, etc., taken from Le Blanc.

It was not possible to determine the E.P. of tungsten in aqueous solutions of its salts, because the salts of tungsten, *e.g.*, the hexachloride and hexabromide, are readily decomposed by water. Fischer²² and others have found that WCl₆ dissolves very readily in many organic solvents without decomposition, and that some of the solutions are quite conducting. Fischer chose, as a specific solvent, absolute ethyl alcohol, and measured the E.P. of W | WCl₆ in solutions of varying concentrations of WCl₆, using, as an auxiliary electrode, a calomel half cell, the electrolyte of which was a saturated solution of lithium chloride in alcohol. He found that a 0.102 n (molecular) solution of WCl₆ produced, along with the auxiliary half cell, an emf. of 0.465 volt, the tungsten being positive. From this value he calculated the E.P. of W | 1/1 n (ionic) sol. WCl₆ to be 0.680* volt (H = O). He also calculated the E. P. H₂O — C₂H₅OH to be 0.071 volt. He assumes that

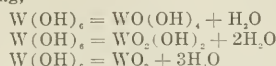


and substituting the values obtained above he gets

$\text{EP W} - \text{WCl}_6(\text{H}_2\text{O}) = 0.609 \text{ volt}^* (\text{H} = \text{O})$
a hypothetical value. He decides that W lies between Sb and Hg in the electrochemical series given by Le Blanc.

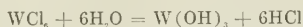
Analogous to Fischer's experiments, we thought it possible to find the E.P. of W in saturated solutions of W(OH)₆ in 1/1 n HCl, H₂SO₄, and HNO₃, and from the E.P.'s obtained to calculate the E.P.'s in 1/1 n (ionic) solution of W(OH)₆. The solutions of W(OH)₆ were prepared by electrolyzing the solvents between tungsten electrodes until a copious excess of yellow precipitate was obtained. The anode during electrolysis in each case went through a series of color changes from brown through blue to yellow, after which tungstic acid was precipitated from the solution. These color changes will be discussed later. We considered the solvents saturated with W(OH)₆ when the precipitate began to form. The reactions which take place at the anode during electrolysis produce a hydroxide of tungsten, which dissolves to saturation and ionizes. When the solvent is saturated with ions, the molecular W(OH)₆ being un-

stable, breaks down to H₂WO₄ and analogous compounds by the loss of water. The reactions expressing these changes being,



The end product, anhydrous WO₃, is probably never reached in this case.

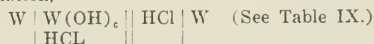
Analogous reactions occur between ionic chlorine and tungsten. Tungsten hexachloride forms and dissolves. Being unstable in water, it immediately decomposes to W(OH)₆.



W(OH)₆ dissolves to saturation and the excess breaks down to WO₃ in the same manner as in the above case. In case either Cl ions or OH ions are discharged at the anode, the end products will be the same. Analogous reactions occur in HNO₃ and H₂SO₄ solutions.

That W and Cl ions do unite to form WCl₆ has been shown by electrolyzing a saturated solution of HCl (gas) in absolute ethyl alcohol between tungsten electrodes which have been separated by a porous cup. The anode solution becomes colored yellow by the dissolved WCl₆ that has been formed.

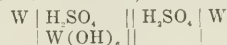
Our emf. measurements, Table IX, have shown that W(OH)₆ is not only soluble in 1/1 n HCl, H₂SO₄, and HNO₃, but also that the W(OH)₆ is ionized to W ions and OH ions. It is dissolved as a true solution and not a colloidal solution, though some colloidal tungstic acid may be present in the solution. Unless the W(OH)₆ were ionized, no emf. would have been obtained in the combination,



We have assumed that the dissolved tungsten is present as a hydroxide, W(OH)₆, and that this hydroxide ionizes to W ions and OH ions in the same manner that Pb(OH)₂ ionizes to Pb ions and OH ions in the lead accumulator.²³⁻²⁴ According to Dolezalak,²⁴ PbO₂ hydrolyzes to Pb(OH)₄, which ionizes to a tetravalent lead ion and four OH ions.

If W(OH)₆ is an amphoteric electrolyte,²⁵ the tungsten in solution must migrate as cations to the cathode in acid solution, and as anions to the anions in alkaline solution.²⁶

From direct measurements, the combination



gave an emf. of +0.117 volt with the tungsten in the W(OH)₆ as positive. This shows that the half cell W | W(OH)₆ is 0.117 volt more positive than the half

H₂SO₄ cell in which there is no W(OH)₆ in solution. The combination is a concentration cell, the right-hand member being the more dilute with respect to W(OH)₆.

According to Nernst,²⁷ the dilute solution always presents the sign of the more rapidly moving ion. It is obvious that the mobility of the OH ion is much greater than that of the W ion. The more dilute solution will then be negative to the more concentrated with respect to W(OH)₆. The concentration of the H and the SO₄ ions are approximately the same in both half cells.

If instead of having W(OH)₆ in solution, we had paratungstic acid, H₂W₂O₇, or ortho tungstic acid, H₂WO₄, we would have WO₃ ions and an increased number of H ions in the right-hand half cell (assuming H₂WO₄ dissolved). Since the H ion is more mobile than the WO₃ ion, the more dilute solution would then be positive. Experiment showed, however, that the more dilute solution is negative, taking the sign of the more mobile of the ions resulting from the dissociation of

*Fisher has confused his signs in his calculations.

the $W(OH)_6$. Tungsten must then exist as the cation in solution, and the solution must contain $W(OH)_6$.

Tables VII, VIII and IX give the results of the experiment.

TABLE VII—1/1 N ACIDS, NO $W(OH)_6$ ADDED—MEASURED WITH AUXILIARY CAL. ELECTRODE +0.56 V.

1	2	3	4	5	6	7	8
1/1 n Acid	E.M.F.	E.P. W sol cal = +0.56	E.P. KCl sol	E.P. W sol Corrected cal = +0.56	E.P. W sol cal = 0	E.P. W sol Corrected cal = 0	E.P. W sol H = 0
H_2SO_4	Volts	Volts	Volts	Volts	Volts	Volts	Volts
HCl	+0.058	+0.502	-0.030	+0.472	-0.058	-0.088	+0.195
HNO_3	-0.006	+0.566	-0.029	+0.537	+0.006	-0.023	+0.260
	-0.054	+0.614	-0.029	+0.585	+0.054	+0.025	+0.308

TABLE VIII—1/1 N ACIDS SAT. WITH $W(OH)_6$ —MEASURED WITH AUXILIARY CAL. ELECTRODE +0.56 V.

1	2	3	4	5	6	7	8
1/1 n Acid	E.M.F.	E.P. W sol cal = +0.56	E.P. KCl sol	E.P. W sol Corrected cal = +0.56	E.P. W sol cal = 0	E.P. W sol Corrected cal = 0	E.P. W sol H = 0
H_2SO_4	Volts	Volts	Volts	Volts	Volts	Volts	Volts
HCl	+0.063	+0.620	-0.030	+0.590	+0.063	+0.030	+0.313
HNO_3	+0.063	+0.623	-0.029	+0.594	+0.063	+0.034	+0.317

TABLE IX—HALF CELL COMBINATIONS

+W H_2SO_4 / H_2SO_4 W- $W(OH)_6$	+0.117 volts
+W HCl / HCl W- $W(OH)_6$	+0.037 volts
+W HNO_3 / HNO_3 W- $W(OH)_6$	+0.009 volts

In Table VII the E.P.'s of W in N acid sol. are shown. Table VIII shows the E.P.'s of W in N acid solutions saturated with $W(OH)_6$. Table IX shows the order of solubility of $W(OH)_6$ in the three acids. It is least soluble in HNO_3 and most soluble in H_2SO_4 . In each of the three cases the e.m.f. is the result of the difference of concentrations in the two members of the cell. The concentrations of $W(OH)_6$ in the right hand members are very small. We determined the amount of $W(OH)_6$ that is dissolved in the three 1/1 N acid solutions to saturation by evaporating a large volume of the solution to dryness, igniting and weighing as WO_3 . We find

0.02281 gm. WO_3 [= 0.02816 gm. $W(OH)_6$]
per 1000 c.c. n n H_2SO_4
0.01067 gm. WO_3 [= 0.01315 gm. $W(OH)_6$]
per 1000 c.c. n n HCl
0.00025 gm. WO_3 [= 0.00030 gm. $W(OH)_6$]
per 1000 c.c. n n HNO_3

If we try to calculate the concentration of the $W(OH)_6$ solution by means of the modified Nernst formula

$$EP = \frac{0.058}{V} \log \left(\frac{C_1}{C_2} \right)$$

Where C_1 and C_2 are the ionic concentration, we run into difficulties. We cannot calculate the concentration of $W(OH)_6$ from conductivity measurements because the conductivity of the 1/1 n acid solutions are so high and the concentration of the $W(OH)_6$ is so low that the increase in conductivity due to $W(OH)_6$ would not be much greater than a value due to experimental error.

From the values of concentration found by evaporating to dryness, we can calculate the E.P. for W | 1/1 n $W(OH)_6$.

$$EP_n = EP - \frac{0.058}{v} \log c$$

This was found to be +0.336 volt in n H_2SO_4 , +0.342 volt in n HCl and 0.358 volt in n HNO_3 .

Anodic Behavior of Tungsten in Electrolytes

Le Blanc²⁸ studied the anodic behavior of tungsten in various electrolytes, and found that in 1/1 n solutions of H_2SO_4 , HCl and HNO_3 the metal becomes passive. In KOH, NH_4OH , NaOH, however, he found that the metal stays active within wide ranges of current density. If, however, the current density reaches or exceeds a maximum in alkaline solutions, tungsten becomes passive. Interrupting the current for a short time destroys the passivity.

From experiments which we have made, we have noticed that when 1/1 n solution of HCl, H_2SO_4 , HNO_3 , KF, KCl, KBr, KI, K_2SO_4 , and KNO_3 are electrolyzed between tungsten electrodes separated by a porous cell, the anode always becomes coated with a series of films ranging in color from brown through purple, dark blues, light blues, greens, to yellow. The color changes are independent of the nature of the anions and cations in the solution used, but are dependent upon the current density and the time of electrolysis.

With an initial current density of approximately 0.00025 ampere per square dm., the color changes of the film on the anode can be very easily followed. I use the term initial current density to denote the current at the start. As the electrolysis proceeds, the resistance of the film increases and the current flowing is decreased. The first flash of brown color is quite marked and the change from brown to purple is also quite marked. The change to dark blue and to light blues is slower, and it is difficult to tell when the greens stop and the yellow begins. The change from green to yellow is gradual. These changes are a function of current density and time. Tables XI, XII, XIII give some comparative figures on three runs which we made with a 1/1 n solution of KCl.

If the initial current density be increased to 2 amp. per dm², the anode assumes a yellow color almost immediately. The eye, not being quick enough to follow the color change from brown to yellow, sees only the yellow.

TABLE XI

Time, Sec.	Current, Amp.	Back E.M.F., Volt	Color
0	0	0	Gray (tungsten)
2	0.0400	1.325	Brown
5	...	1.350	Purple-brown
7	...	1.350	Purple
10	...	1.350	Dark blue
12	...	1.375	Light blue
20	0.0270	1.425	Green blue
30	0.0235	1.460	Olive green
60	0.0175	1.480	Yellow green
80	0.0165	1.50	Yellow
100	0.0150	1.54	Yellow

TABLE XII

Time, Sec.	Current, Amp.	Back E.M.F., Volt	Color
0	0	0	
2	0.065	1.0	Brown
5	...	1.1	Purple-brown
7	...	1.1	Light blue
10	0.035	1.15	Light blue
15	...	1.225	Green blue
20	0.028	1.25	Yellow-green
30	0.025	1.325	Yellow

TABLE XIII

Time, Sec.	Current, Amp.	Back E.M.F., Volt	Color
0	0	0	
2	0.095	0.93	Brown
5	...	1.10	Light blue
7	...	1.10	Light blue
10	0.045	1.20	Green blue
15	...	1.25	Yellow
20	0.040	1.35	Yellow

Rosenheim obtained a similar series of colored oxides in reversed order by the cathodic reduction of H_2WO_4 . He started with yellow and ended with brown WO_3 . Our results are analogous to his in that we have the same series of colors formed electrolytically, but differ from his results in that we have anodic oxidation and Rosenheim had cathodic reduction.

In the literature we find mention made of many tungsten oxides. Some of these are:

WO	Black ²⁹
WO_2	Brown ³⁰
W_2O_5	Blue ³¹
W_2O_{11}	Blue ³²
W_2O_{11}	Green Blue ³³
WO_3	Yellow ³⁴

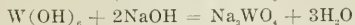
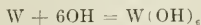
Mixtures of these oxides produce intermediate colors. Brown and blue give purple; blue and yellow give green. These colors agree with the colors obtained by the anodic oxidation of tungsten.

It is obvious that the degree of passivity depends on the nature of the oxide film which covers the tungsten. The brown oxide is less noble than the blue or the yellow.

When the current density is very low, and the volume of electrolyte is very large, and the diffusion comparatively rapid, no passivity was observed and no colored films were formed until the electrolyte had become saturated with $\text{W}(\text{OH})_6$. Passivity in this case is accompanied by a cloudy precipitate. Passivity is a function of the volume of electrolyte used and the rate at which the anode products are dissolved. The solubility of the anode films was shown by allowing a "passified" anode, which had been thoroughly washed with distilled water after electrolysis, to stand in fresh unused portions of the same electrolyte in which it had been made passive for an hour or two. The time depended on the electrolyte.

A sample of "passified" tungsten became "active" by allowing to stand over night in a tightly sealed bottle of freshly distilled water. Solution of NaOH, KOH, NH_4OH , etc., make "passive" tungsten "active" almost instantly. The passivity of tungsten is due to a film of adherent oxide or hydrated oxide, and is a function of the rate R at which the film is produced, and the rate R_1 at which the film is dissolved into the solution used to produce it. If $R = R_1$ we have equilibrium, while if $R > R_1$ the metal becomes passive.

We have found that tungsten dissolves anodically in aqueous solution of NaOH and KOH with the formation of the respective ortho tungstates.



Passivity occurs only when the current density is so high that the rate of formation of $\text{W}(\text{OH})_6$ is faster than the rate of solution and diffusion in NaOH.

We have found that tungsten dissolves anodically in a solution of HCl (gas) in absolute ethyl alcohol without becoming passive and without the liberation of gas. The anode solution becomes yellow, due to the dissolved WCl_6 , and the cathode solution becomes green, due to reduction.³⁵

We have found that tungsten dissolves anodically in NH_4OH , NH_2OH , the four methyl ammonium hydroxides, the four ethyl ammonium hydroxides, and propyl ammonium hydroxides within wide limits of current density without becoming passive. The first product of the reaction, $\text{W}(\text{OH})_6$, dissolves on the electrolyte to form salts.

Ekeley³⁶ has found that $\text{H}_2\text{W}_2\text{O}_7$ dissolves in amines

to form salts which are analogous to $(\text{NH}_4)_6\text{W}_2\text{O}_{24}$. As an example:

$\text{H}_2\text{W}_2\text{O}_7$ with $\text{C}_2\text{H}_5\text{NH}_2\text{OH}$ forms $(\text{C}_2\text{H}_5\text{NH}_4)_6\text{W}_2\text{O}_{24} \cdot 5\text{H}_2\text{O}$. His analysis of the salts conforms with his formulae.

Electrolyzing $\text{C}_2\text{H}_5\text{NH}_2\text{OH}$ between tungsten anodes produces $(\text{C}_2\text{H}_5\text{NH}_4)_6\text{W}_2\text{O}_{24} \cdot 5\text{H}_2\text{O}$. Analogous salts are obtained with

$\text{CH}_3\text{NH}_2\text{OH}$; $(\text{CH}_3)_2\text{NH}_2\text{OH}$; $(\text{CH}_3)_3\text{NHOH}$; $(\text{CH}_3)_4\text{NOH}$
 $(\text{C}_2\text{H}_5)_2\text{NH}_2\text{OH}$; $(\text{C}_2\text{H}_5)_3\text{NHOH}$; $(\text{C}_2\text{H}_5)_4\text{NOH}$
 $(\text{CH}_3)_3\text{NH}_2\text{OH}$; $(\text{CH}_3)_2\text{N}_2\text{HOH}$, etc.

In NH_4OH tungsten dissolves anodically with a valence of 6 and 100 per cent efficiency to produce ammonium paratungstate $(\text{NH}_4)_6\text{W}_2\text{O}_{24}$. NH_4Cl was added to increase the conductivity of the solution. In conjunction with this experiment, we determined, from the loss in weight of the anode, the electrochemical equivalent of tungsten and found that when the metal dissolves with a valence of 6 the value of the electrochemical equivalent was 0.3173 mg. per coulomb. The theoretical value calculated from the formula

$$E_{100} = \frac{\text{At Wt}}{\text{Valence} \times 96580} = \frac{184}{6 \times 96580}$$

is 0.3175 mg. per coulomb³⁷.

We have found that tungsten also dissolves anodically in NH_4OH . We have not determined the salt formed, but it is probably analogous to ammonium paratungstate.

The anodic behavior of tungsten in aliphatic substitution products of NH_4OH , and the aromatic hydroxyl compounds and substitution products will be discussed in a future paper.

The Use of Tungsten in Cells

Fink³⁸ mentions the use of tungsten in cells in a paper on "The Applications of Ductile Tungsten," and promises good results both in voltaic and in standard cells. We have since made a further study of these two types of cells and taken up the application of W to storage cells.

VOLTAIC CELLS

If W is to be used as anode in a voltaic cell, it is desirable to use an electrolyte in which both the tungsten and the anodic-reaction products are most soluble. Barring KCN, tungsten is most soluble in solutions of KOH or NaOH. The E.P. W | sol. will be algebraically lowest (or in commoner terms the highest — value) in NaOH solutions³⁹. In addition to the anode, it is desirable to have as a cathode, a metal, the E.P. of which is a high + value in the same electrolyte (if possible). Hg and Ag are two such metals.

Mercury has an E.P. in a saturated solution of HgO in 1/1 n. NaOH of +0.445 volt⁴⁰ compared to calomen = +0.56, or —0.115 compared to cal. = O, or +0.168 volt compared to H = O. Silver in a saturated solution of Ag_2O in 1/1 n. NaOH has an E.P. of +0.655 volt⁴¹ when cal. = +0.56, or +0.378 when H = O. The E.P. W | NaOH = —0.039 when cal. = +0.56, or —0.316 when H = O.

The emf. of the combinations

Hg | HgO | NaOH || NaOH | W
 and Ag | Ag_2O | NaOH || NaOH | W

will then be respectively

$$(+0.445) + (-0.039) = 0.484 \text{ volt}^{42}$$

$$(+0.655) + (-0.039) = 0.694 \text{ volt}^{43}$$

The mercury and silver are both positive to the tungsten.

To increase the emf. of the cell it is only necessary to increase the concentration of the NaOH solution.

TABLE XIV

Normality of NaOH	E.M.F. Fused W.	Powdered W.
	Volts	Volts
10	0.595	1.650
5	0.575	1.605
2	0.530	0.920
1	0.484	0.870
0.5	0.440	0.822
0.2	0.381	0.777
0.1	0.343	0.730
0.05	0.315	0.695

The results are very promising with tungsten, both as fused slugs and as metal powder. In our preliminary tests the metal powder has given higher emf. values than the fused metal.

Following are readings taken on a small experimental cell. The voltage was read across the electrodes of the cell. Resistance was put in series with the cell and the ammeter.

Volts	Ampe.
1.05	Open
0.95	0.0037
0.90	0.0120
0.80	0.0220
0.60	0.0410
0.40	0.0640
0.20	0.0850
0.10	0.0950
0.05	0.1000
0.01	0.1020

Other cells in which W enters either as metal or compound are being studied.

STANDARD CELLS

In connection with the use of tungsten in standard cells we have made the following observations:

TABLE XV

1 Electrodes	2 E.M.F.	3 E.P. Sol ¹ Metal HgO = +0.445
Sat. Na ₂ W ₂ O ₇ /Hg ₂ W ₂ O ₇ /Hg	-0.401 Volts	-0.846 volts
Sat. Na ₂ W ₂ O ₇ /Cu ₂ W ₂ O ₇ /Cu	-0.235	-0.690
Sat. Na ₂ W ₂ O ₇ /W	+0.152	-0.297
Sat. Na ₂ W ₂ O ₇ /Zn ₂ W ₂ O ₇ /Zn	+0.302	-0.143
Sat. Na ₂ W ₂ O ₇ /Cd ₂ W ₂ O ₇ /Cd	+0.583	+0.138

Single potential measured with auxiliary electrode Hg | HgO | NaOH = +0.445 volt.

Combining these single electrodes one with another we obtained the combinations which gave the emfs. as shown in Table XVI.

The emf.'s of the combinations check up very well with the theoretical emf.'s calculated from the E.P.'s of the single electrodes, Table XV.

These cells are still under investigation and further reports on tests made on their temperature coefficients, life and stability will be given.

TUNGSTEN STORAGE BATTERY

At present we have under investigation several cells made with combinations of tungsten and tungsten oxides.

These cells, A, B, C (Table XVII), were made with tungsten and tungstic acid. The three combinations are shown in the table. Cell A had tungsten and tungstic acid as the positive electrode and tungsten metal

TABLE XVI

+	Hg	Hg ₂ W ₂ O ₇	Na ₂ W ₂ O ₇ sat.	Na ₂ W ₂ O ₇ sat.	W	= +0.552 volts
+	Cu	Cu ₂ W ₂ O ₇	Na ₂ W ₂ O ₇ sat.	Na ₂ W ₂ O ₇ sat.	W	= +0.395
-	Zn	Zn ₂ W ₂ O ₇	Na ₂ W ₂ O ₇ sat.	Na ₂ W ₂ O ₇ sat.	W	= +0.154 volts
-	Cd	Cd ₂ W ₂ O ₇	Na ₂ W ₂ O ₇ sat.	Na ₂ W ₂ O ₇ sat.	W	= +0.434
+	Hg	Hg ₂ W ₂ O ₇	Na ₂ W ₂ O ₇ sat.	Na ₂ W ₂ O ₇ sat.	Cd ₂ W ₂ O ₇	Cd = +0.981 volts
+	Hg	Hg ₂ W ₂ O ₇	Na ₂ W ₂ O ₇ sat.	Na ₂ W ₂ O ₇ sat.	Zn ₂ W ₂ O ₇	Zn = +0.703
+	Hg	Hg ₂ W ₂ O ₇	Na ₂ W ₂ O ₇ sat.	Na ₂ W ₂ O ₇ sat.	Cu ₂ W ₂ O ₇	Cu = +0.131
+	Cu	Cu ₂ W ₂ O ₇	Na ₂ W ₂ O ₇ sat.	Na ₂ W ₂ O ₇ sat.	Cd ₂ W ₂ O ₇	Cd = +0.831 volts
+	Cu	Cu ₂ W ₂ O ₇	Na ₂ W ₂ O ₇ sat.	Na ₂ W ₂ O ₇ sat.	Zn ₂ W ₂ O ₇	Zn = +0.537
+	Zn	Zn ₂ W ₂ O ₇	Na ₂ W ₂ O ₇ sat.	Na ₂ W ₂ O ₇ sat.	Cd ₂ W ₂ O ₇	Cd = +0.283

as the negative before charging. Cell B had tungsten and tungstic acid as both electrodes, while cell C had tungsten-tungstic acid as negative electrode and tungsten as positive, being the reverse of A, before charging. The cells were connected in series and charged. The emf. of each cell was measured immediately after charging and found to be 3.00 volts for cell A, 3.20 volts for cell B, and 6.20 volts for cell C. Twenty-four hours after charging the cells, the emf.'s had dropped to 0.2 volt, 0.55 volt and 0.85 volt respectively. The cell C having W | WO₃ as positive electrode and W | WO₃ as negative electrode has so far been the most satisfactory.

TABLE XVII—BEFORE CHARGING

Type	Positive Electrode	Negative Electrode	E.M.F.
A	W | WO ₃ · xH ₂ O	W	+0.08
B	W | WO ₃ · xH ₂ O	WO ₃ · xH ₂ O | W	0
C	W	WO ₃ · xH ₂ O | W	-0.08

TABLE XVIII—AFTER CHARGING

Type	Positive Electrode	Negative Electrode	After Charging, E.M.F.	24 Hours After Charging, E.M.F.
A	W | WO ₃ · xH ₂ O	W	Volts +3.00	Volts +0.2
B	W | WO ₃ · xH ₂ O	Blue W | WO ₃ · xH ₂ O	+3.20	+0.55
C	Brown W | WO ₃ · yH ₂ O	Blue W | WO ₃ · xH ₂ O	+6.20	+0.85

The results obtained with tungsten storage cells are very promising and will be discussed more fully in a more detailed paper which will follow.

Summary

1. A brief review of the literature is given.
2. The single potentials of tungsten in n/n solutions of acids, alkalies and neutral salts were calculated from e.m.f. measurements.

From emf. measurements and calculated E.P. we have found that:

3. Tungsten has a lower potential in $n, 1$ alkalis than in $n, 1$ acids and a lower potential in $n, 1$ acids than in $n, 1$ solutions of neutral salts.

4. Tungsten has a lower potential in $n, 1$ KCN solutions than in $n, 1$ solutions of KOH (or NaOH) and a lower potential in the latter than in a $n, 1$ NH_4OH solution. The potential in $n, 1$ KOH (or NaOH) corresponds to that of thallium in a thallium chloride solution containing $n, 1$ TI ions.

5. Tungsten has a lower potential in $n, 1$ H_2SO_4 than in $n, 1$ HCl , and a lower potential in the latter than in $n, 1$ HNO_3 . The potential of W in HNO_3 corresponds to that of Cu in a CuCl_2 solution containing $n, 1$ Cu ions.

6. The order of potential of W in $n, 1$ solutions of neutral salts is as follows: KNO_3 , KF , KBr , KCl , K_2SO_4 , KI , the potential being highest in solutions of KI .

7. It is shown that in solutions of tungsten in acids, tungsten occurs as cation, whereas in alkaline solutions tungsten occurs in the anion.

8. Tungstic acid is more soluble in $n, 1$ H_2SO_4 than in $n, 1$ HCl and more soluble in $n, 1$ HNO_3 . Direct chemical tests confirm this.

9. Tungstic acid hydrolyzes and goes into solution as $\text{W}(\text{OH})_6$ in $n, 1$ solution of H_2SO_4 , HCl , HNO_3 . W appears in the cation.

10. $\text{W}(\text{OH})_6$ in water is an electrolyte and not a colloid.

11. Tungsten dissolves anodically in aqueous and non-aqueous solutions of alkalis, acids and salts.

12. Tungsten anodes become passive in aqueous and non-aqueous solutions of alkalis, acids and salts.

13. Tungsten becomes passive in aqueous solution of alkalis and organic solutions of alkalis, acids and salts only at very high current densities.

14. Tungsten becomes passive in aqueous solutions of acids and salts even at low current densities. It stays active in these solutions only at very low current densities.

15. The passivity of tungsten is due to adherent films of hydrated tungsten oxides. The films may be readily dissolved and the passivity of the metal thereby destroyed.

16. The hydrated oxide films appearing on the anode vary in color from brown, thru blue to yellow. The degree of passivity varies with the color of the film.

17. The passivity phenomena observed can be readily interpreted by the oxide theories of passivity.

18. The electrochemical equivalent of tungsten was found to be .3173 mg. per coulomb. This corresponds very closely with the theoretical.

19. Experiments on the use of tungsten in voltaic, standard and storage cells are recorded. The phenomena observed in connection with the storage cell are of particular interest. The potential difference between brown oxide (positive) and blue oxide (negative) is $+0.75 \text{ V}$.

This work was carried out in the research laboratory of the Edison Lamp Works, Harrison, N. J., under the direction of Dr. C. G. Fink.

Harrison, N. J.

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¹⁷Ostwald-Luther, Phys.-Chem. Mess. S. 445.

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²¹Fischer, Zeit. Anorg. Chem. 81 (1913), 170-208.

²²Le Blanc, Text Book of Electrochemistry, page 80.

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²⁴Bredig, Zeit. Elek. Chem. 6 (1899), 33. Zeit. Anorg. Chem. 34 (1903), 202.

²⁵Walker, Zeit. Phys. Chem. 49 (1904), 82.

²⁶Le Blanc, Text Book of Electrochemistry, page 80.

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²⁸Le Blanc and Byers, Zeit. Physik Chem. 69, 19.

²⁹Fischer, Zeit. Anorg. Chem. 81 (1913).

³⁰Warr, An. Ch. Ph. (2) 29, 43 (1823), Hallepeau, C. R. 127, 512 (1898).

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³⁸C. G. Fink, Trans. Am. Elect. Soc. 17 (1913), 229. Jour. Ind. & Eng. Chem., V. (1913), 8. Chemical News, 107 (1913), 282.

³⁹See table III.

⁴⁰See Ostwald-Luther, Phys.-Chem. Mess.

⁴¹Ostwald-Luther, Physiko-Chemische Messungen.

⁴²See table III-A.

⁴³See table III-B.

Stability of Paraffin Hydrocarbons

By Gustav Egloff and Robert J. Moore

(Contribution from the Havemeyer Chemical Laboratory, Columbia University No. 291.)

In current opinion there exists a belief in regard to paraffin hydrocarbon stability that has become almost axiomatic, namely, that with increase in the boiling point and greater complexity of the molecule, hydrocarbons are the more readily decomposed, either into their ultimate products or into intermediate compounds. It is the aim of this research to show that such a belief is untenable.

A statement such as the following, "It is well known that the simpler petroleum hydrocarbons are stable at much higher temperatures than those of higher molecular weight," is met with time and again, but no specific references to experiments which verify it can be found. This opinion seems to have originated from the results of simple atmospheric distillation of crude petroleum where cracking has been noted at approximately 200 deg. C. and upward,¹ after the lower-boiling-point paraffins have been distilled off. But the latter have not been subjected to the higher temperatures. If now we take these low-boiling-point paraffin hydrocarbons, and also those boiling at 200 deg. C. and upward, and subject them to a higher temperature, say 700 deg. C., their true relative stability could then be determined. This is essentially the scope of the following investigation.

It will be shown experimentally that stability is not a direct function of the complexity of the paraffin chain molecule, but that if stability is graphed against the boiling points of the paraffins there results a curve having the maximum stability at about 250 deg. C. representing the compounds ($\text{C}_{12}\text{H}_{26}$ to $\text{C}_{14}\text{H}_{30}$), minima at the lowest boiling points (C_2H_6 to C_4H_{10}) and the highest boiling points ($\text{C}_{20}\text{H}_{42}$ to $\text{C}_{22}\text{H}_{46}$). The above compounds have been isolated from a Pennsylvania paraffin base petroleum oil.² Stability will be given in

¹Bacon and Hamor, American Pet. Industry, Vol. II, p. 558, 1916.

²Zaloziecki, Zeit. Angew. Chem. 620, 1897.

Engler, Berichte, 30, 2909.

Engler-Höfer, Das Erdöl, 495, 562, Vol. I.

The following paraffin hydrocarbons have been isolated from Pennsylvania crude petroleum.

C_2H_6 Warren Proc. Amer. Academy 27, 56-92, Zeit. f. Chem. 242, 1865.

C_4H_{10} Schorlemmer, Berichte 3, 615, 1870; 4, 395, 561, 1871; 5, 297, 1872.

C_6H_{14} Schorlemmer, J. Chem. Soc. [2] 1, 216, Am. Phys. Chem. 136, 257, 1866.

C_8H_{18} Warren, Ibid.

$\text{C}_{10}\text{H}_{22}$ Warren, Loc. cit.

$\text{C}_{12}\text{H}_{26}$ Maberry, Proc. Amer. Acad. 32, 129, 1897.

$\text{C}_{14}\text{H}_{30}$ Maberry, Ibid.

$\text{C}_{16}\text{H}_{34}$ Maberry, Amer. Chem. J. 19, 419-482.

$\text{C}_{18}\text{H}_{38}$ to

$\text{C}_{22}\text{H}_{46}$ Maberry, Loc. cit.

$\text{C}_{24}\text{H}_{50}$ Maberry, Proc. Amer. Acad. 40, 349, 1904.

terms of per cent, specific gravity and refractive index of the recovered oils, and in the distillation analysis and aromatic formation in the recovered oils, compared with the original fractions, per cent to carbon and gas; and volume of gas formed.

General Procedure

A Pennsylvania paraffin base crude oil was fractionated in cuts to 150 deg. C., 150-200 deg., 200-250 deg., and above 250 deg. C. under vacuum into cuts of 50 deg. each. The residue, a semi-solid, was discarded. After the specific gravity, index of refraction, per cents of unsaturated and nitratable hydrocarbons were determined, each fraction was then subjected to a temperature of 700 deg. C. in an electrically heated furnace by passing the oil through at the rate of 200 c.c. per hour. The volume of gas formed was taken and its unsaturation and hydrogen content determined. The recovered oils were measured and analyzed as follows: distillation, specific gravity, refractive index, unsaturateds, and benzene, toluene and xylene content.

Specific gravities were taken with the Westphal balance at 15.5 deg. C., and where amounts were small with a 1 c.c. capacity pycnometer. A Pulfrich refractometer was used for index of refraction values. Unsaturation and nitrative methods of procedure have been previously published.¹

The distillation was conducted by means of a Glinzky distilling head and the fractions made after several redistillations according to a method previously described.² The cut to 95 deg. C. represented the benzene fraction, 95 to 120 deg. C. the toluene fraction, and from 120 to 150 deg. C. the xylene fraction.

Analysis of Starting Oil.

The Pennsylvania petroleum crude oil was distilled by means of a 3 liter Engler distillation flask in two 1800 c.c. portions in fractions up to 150 deg., 150 to 200 deg. C., 200 to 250 deg. C., and in vacuum at 150 deg. to 200 deg. C., and from 200 deg. to 250 deg. C. Distillation in vacuum was carried on, due to cracking taking place at 250 deg. C. and atmospheric pressure. These fractions for simplicity's sake will be called subsequently fractions A, B, C, D, E.

TABLE 1—ANALYSIS PETROLEUM CRUDE OIL

Temperature, Deg. C.	A	B.	C.	D.	E.
of Fractions to 150	150-200	200-250	150-200, 200-250,	200-250,	
Per cent by volume.....	18.8	15.5	13.1	13.3	12.1
Specific gravity.....	0.724	0.763	0.786	0.811	0.833
Refractive index.....	1.40156	1.42271	1.43507	1.44773	1.45872
Per cent unsaturated 1.5	2.5	1.0	1.5	0.5	
Per cent nitratable hydrocarbons	3.0	7.0	1.5	5.5	4.5

FURNACE USED

The furnace used for the following work was electrically heated over a length of 18 in., and has been described in detail elsewhere.⁴

DETAILS OF THERMOLIZATION

For each run 300 c.c. of the oil were passed at the rate of 200 c.c. per hour in the cracking zone. The temperature of this area was kept constant at 700 deg. C. within + or - 5 deg. C. The temperature was recorded by means of a base-metal thermocouple calibrated against a platinum-iridium standard. The condenser was surrounded with ice and the recovered oil collected in a receiver, while the gas passed through a standard referee wet meter and collected directly into a Hempel burette for analysis. The volume registered

on the meter in cubic feet was converted to liters by the factor 28.315. The gas was analyzed for unsaturated hydrocarbons by fuming H_2SO_4 , which although it is known to absorb a certain per cent of the higher paraffins⁵ was nevertheless sufficiently accurate for this work.

The hydrogen content of the gas was determined by means of Jaeger's fractional combustion method modified by Whitaker and Leslie.⁶ A discussion of this method has been made by Burrell and Oberfell,⁷ and also by Porter and Taylor.¹⁰

A. The Percentage, Specific Gravity and Refractive Index of the Recovered Oils

TABLE 2

Temperature, Deg. C.	A	B.	C.	D.	E.
of Fractions to 150	150-200	200-250	150-200, 200-250,	200-250,	
Per cent recovered oil by volume.....	2.3	29.3	66.7	25.0	20.0
Specific gravity.....	0.777	0.790	0.794	0.858	0.953
Refractive index.....	1.43663	1.44076	1.44206	1.46486	1.49428

The stability of the hydrocarbons present in the fractions at 700 deg. C. increased as the boiling points increased, reaching a maximum in the cut 200 to 250 deg. C. and then decreased. The least stable of the hydrocarbons were those boiling to 150 deg. C., which contained mainly the paraffin hydrocarbons pentanes to nonanes.

The percentage yield of the recovered oils from the thermolized fractions indicates quite clearly the gradient of the stability of the starting, mainly paraffin hydrocarbons. The paraffins apparently reached a maximum stability under the conditions of the experiment in the cut of 200 to 250 deg. C., and then decreased in the higher boiling point fractions. This fact is brought out quite forcibly when one takes the values of the percentage of the starting fractions decomposing to form gas and carbon (Table 3).

TABLE 3—THE PERCENTAGE OF STARTING FRACTIONS DECOMPOSED TO FORM CARBON AND GAS

Temperature, Deg. C.	A	B.	C.	D.	E.
Per cent to carbon and gas.....	97.7	70.7	33.3	75.0	80.0

The maximum of 97.7 per cent occurs in the lowest boiling point paraffin hydrocarbon fraction and reaching a minimum of 33.3 per cent in fraction C, while a maximum is also shown in fraction E of 80 per cent. The most stable paraffins are those somewhat midway between the two extreme boiling point paraffin hydrocarbons.

The specific gravity of the recovered oils increases from the lowest to the highest boiling point fraction, although not markedly higher than the values of the starting fractions, except the fraction boiling in vacuum between 200 and 250 deg. C. Table 4 tabulates the two sets of values:

TABLE 4

Temperature, Deg. C.	A	B.	C.	D.	E.
of Fractions to 150	150-200	200-250	150-200, 200-250,	200-250,	
Sp. gr., original fraction.....	0.724	0.763	0.786	0.811	0.833
Sp. gr., thermolized fractions	0.777	0.790	0.794	0.858	0.953

In each case the thermolized oil shows a higher specific gravity value, which is to be expected as apparently in all thermal decomposition work of paraffin hydro-

¹Egloff and Twomey, *Met. and Chem. Eng.* 14, 247, 1916.

²Egloff and Moore, *Ibid.* 15, 387, 1916.

³Rittman, Twomey and Egloff, *Met. and Chem. Eng.* 14, 70, 1915.

⁴Whitaker & Rittman, *J. Ind. Eng. Chem.* 6, 472, 1914.

⁵Andersen and Engelder, *J. Ind. Eng. Chem.* 6, 989, 1914.

⁶Worstall, *J. A. C. S.* 21, 245, 1899.

⁷Orndorff and Young, *Am. Chem. J.* 15, 249, 1893.

⁸Burrell and Seibert, *Bull. Bureau of Mines*, 42, 45, 1913.

⁹Jour. Ind. Eng. Chem. 8, 634, 1916.

¹⁰Jour. Ind. Eng. Chem. 8, 228, 1916.

¹¹Proc. Am. Gas Inst. 9, 255, 1914.

¹²J. Ind. Eng. Chem. 6, 845, 1914.

carbons, aromatic compounds are formed, and these have a higher specific gravity than the paraffins, as shown by averaging those boiling within the limits:

	Average Spec. Gravity Paraffin Hydrocarbons	Spec. Grav. Aromatics
Benzene cut 0° to 95° C.	0.720	0.881
Toluene cut 95° to 120° C.	0.730	0.871
Xylene cut 120° to 150° C.	0.760	0.869

Since the specific gravity of hydrocarbons is an additive property, the physical constant of a thermolized oil would show an increase over the starting paraffin hydrocarbons whenever aromatic compounds were formed.

The specific gravity of the fraction 200 to 250 deg. C. shows the least change in value due to thermolization, which in turn checks up the high per cent of recovery of the starting fraction, and the low per cent decomposing to form carbon and gas.

The refractive index values of the recovered oils increased as the boiling points of the fractions, viz., showing the same tendency as the specific gravity values. A comparison of the refractive index values of the thermolized with the original fractions is shown in Table 5.

Temperature, Deg. C.	A	B	C	D	E
of the Fractions	to 150	150-200	200-250	150-200, 200-250,	200-250,
Refractive index original fractions	1.40156	1.42271	1.43507	1.44773	1.45872
Refractive index thermolized fractions	1.43663	1.44076	1.44206	1.46486	1.49428

The physical constant of refractive index in each case shows a higher value of the fractions after thermolization. Similarly to specific gravity, refractive index is an additive value for hydrocarbons, and will likewise note *percentage* aromatics when present in an oil, due to their higher value when compared to paraffins. A comparison of the refractive indices of paraffin and aromatic hydrocarbons within a similar boiling point range shows the wide difference in the values in the following table:

	Boiling Point Range	Average Refractive Indexes
Paraffins	68 to 174° C.	1.403
Aromatics	80.4 to 167° C.	1.501

The least change in the refractive index value of the thermolized oils occurred in the fraction 200-250 deg. C., where the least thermal decomposition took place under the conditions of the experiment.

TABLE 6. DIFFERENCES IN THE SPECIFIC GRAVITIES AND REFRACTIVE INDEX OF THE ORIGINAL AND THE THERMOLIZED FRACTIONS

Temperature, Deg.	A	B	C	D	E
to 150	150-200	200-250	150-200, 200-250	200-250	Vacuum
Spec. Gravity	0.053	0.027	0.008	0.047	0.120
Refractive Index	0.03507	0.01805	0.00699	0.01713	0.03556

The evidence as to the changes taking place in the original fractions after thermolization is nowhere brought out more clearly than by taking the differences in the specific gravity and refractive index values between the starting and the recovered oils. The values for the specific gravity and refractive index show a minima in both cases in the fraction from 200 to 250 deg.

The specific gravity in fraction C shows a difference of 0.008 in the recovered oil and 0.00699 for the refractive index, which indicates a relatively small change in the composition of the recovered oil from the starting fraction. These two sets of values bring out forcibly the greater stability of the paraffin hydrocarbons (C_6H_6 to $C_{12}H_{22}$) under the conditions of the experiment of 700 deg. C. and rate of oil flow of 200 c.c. per hour, than those boiling below and above this fraction.

B. The liters of gas per liter of oil used, the percentage of unsaturateds and hydrogen in the gas

	TABLE 7	A	B	C	D	E
Temperature, Deg. C.	of the fractions	to 150	150-200	200-250	150-200, 200-250, Vacuum	200-250, Vacuum
Liters of gas per liter of oil used	710.2	560.7	420.4	476.7	514.4	
Percentage unsaturateds	16.1	39.9	40.0	40.6	42.2	
Percentage hydrogen	40.2	24.0	20.5	15.2	13.5	

The liters of gas per liter of oil used decreased to a minimum at the fraction 200-250 deg. C. The maxima were found to be at the lowest and highest fractions. The fraction boiling to 150 deg. C. gave 710.2 liters of gas composed of hydrocarbons and hydrogen. This value is in accord with the other data, indicating the low stability of paraffin hydrocarbons boiling to 150 deg. C. in comparison to the higher boiling point fractions. The minimum of 420.4 liters occurred in the fraction 200-250 deg. C., where the least decomposition of the starting oil took place.

The analysis of the gas samples resulting from the thermal decomposition of the fractions gave an increasing percentage yield of the unsaturateds with a rise in the boiling point of the fractions. The percentage yield of unsaturateds increased from 16.1 to 42.2 in the highest fraction. In the last four fractions only a 2.3 per cent difference of the unsaturateds was noted and three of the values are almost identical.

The hydrogen content of the gas decreased rapidly from 40.2 per cent to 13.5. The maximum hydrogen percentage occurred in the fraction boiling to 150 deg. C., while the minimum occurred at the highest boiling point fraction. As the ultimate products of all thermal decomposition of hydrocarbons are hydrogen and carbon, it is significant as indicating the stability of low boiling point hydrocarbons at elevated temperatures,¹¹ when the percentage yield of the starting 150 deg. C. fraction is 2.3 per cent and the gas analysis 40.2 per cent hydrogen—that in reality they are much less stable at 700 deg. C. than the higher boiling point paraffin hydrocarbons.

C. The distillation analyses of the recovered oils

In the introduction it was stated that one object of this investigation was to show that one of the current hypothesis of paraffin hydrocarbon stability is not tenable, namely, that the higher the boiling point and more complex the molecule, the more readily is it broken up, either into its ultimate products or into intermediate compounds of widely different character. The proof of this untenableness is offered by various experimental results. But of no small value to this end are the distillation figures of the recovered oils, from which some interesting relations may be drawn.

	TABLE 8. DISTILLATION ANALYSIS OF RECOVERED OIL	A	B	C	D	E
Temperature, Deg.	to 150	150-200	200-250	150-200, 200-250, Vacuum	200-250, Vacuum	
To 95	7.0	2.4	1.0	8.8	16.6	
95-120	18.0	8.9	2.6	2.8	10.0	
120-150	35.5	29.4	5.0	2.6	11.1	
150-175	15.3	24.8	15.4	4.0	0.5	
175-200	..	16.5	8.7	2.6	0.8	
200-225	..	10.0	31.5	6.5	2.5	
225-250	..	5.2	19.8	20.0	5.2	
250-275	..	..	8.3	22.9	5.9	

Since our starting oils were mainly pure paraffins whose boiling points ranged from 150 deg. for A to 350 deg. for E, we should expect (if the breaking down of the hydrocarbon is a direct function of the complexity of its molecule) that the distillation fraction to, say, 95 deg. C. of each oil could be expressed graphically in a straight line. That is, that a larger percentage to 95 deg. C. was recovered with increasing boiling point

¹¹Egloff, Met. and Chem. Eng., 16, 692, 1916.

of the starting oil. But such is not the case. The distillation figures for the 95 deg. C. cut show a minima for oil C (B.P. 200-250), the percentages being as follows: 7.0, 2.4, 1.0, 8.8, 16.6 from oils A to E. Fraction 95 deg. to 120 deg. C., which shows the largest boiling point distinction from these higher boiling point originals, also shows a minimum for the oil C. Since the five oils were run under exactly similar conditions, there seems to be no doubt but that these parallel tendencies values, high at each end and lowest at oil C, betoken a characteristic of the latter oil to greater stability under heat. The same conclusion will be arrived at subsequently from other considerations.

D. The Specific Gravity of the Distillation Cuts of the Recovered Oil

TABLE 9

Temperature, Deg.	A.	B.	C.	D.	E.
C	to 150	150-200	200-250	150-200, Vacuum	200-250, Vacuum
To 95	0.790	0.800	0.823	0.874	0.859
95-120	0.744	0.790	0.822	0.873	0.875
120-150	0.761	0.770	0.798	0.865	0.879
150-175	0.767	0.773	0.775	0.861	0.860
175-200	0.780	0.791	0.783	0.851	0.850
200-225	0.790	0.803	0.789	0.842	0.858
225-250	0.796	0.810	0.798	0.836	0.954
250-275	..	..	0.811	0.838	0.967

The specific gravity values of the distillation cuts increased in general with increase of the boiling points of the starting fractions in the cuts to 95 deg. C., 95-120 deg. and 120-150 deg. C. In the distillation cuts above 150 deg. C. the minimum specific gravity values are found to be in fraction C, the mid-boiling point starting oil.

E. The Refractive Index of the Distillation Cuts of the Recovered Oils

TABLE 10

Temperature, Deg.	A.	B.	C.	D.	E.
C	to 150	150-200	200-250	150-200, Vacuum	200-250, Vacuum
To 95	1.42645	1.43431	1.46334	1.49245	1.48870
95-120	1.42534	1.44237	1.46298	1.49246	1.49488
120-150	1.42645	1.42927	1.44600	1.49060	1.50875
150-175	1.43985	1.43038	1.43269	1.48825	1.52998
175-200	1.44880	1.44136	1.43401	1.47713	1.53559
200-225	1.44990	1.45041	1.43683	1.47274	1.54886
225-250	..	1.46288	1.44166	1.46912	1.55088
250-275	..	..	1.44791	1.46585	1.56239

The refractive indices follow somewhat the same trend as the specific gravity values, and simply reinforce the evidence provided by the other physical constants used in these experiments.

F. The percent of unsaturated hydrocarbons in the distillation cuts of the recovered oils

TABLE 11

Temperature, Deg.	A.	B.	C.	D.	E.
C	to 150	150-200	200-250	150-200, Vacuum	200-250, Vacuum
To 95	18.0	5.5	25.0	12.5	17.5
95-120	13.0	10.0	22.0	20.0	25.0
120-150	12.0	5.0	7.5	13.0	20.0
150-175	11.5	5.0	2.5	16.0	23.0
175-200	..	6.0	2.5	9.5	15.0
200-225	..	12.5	5.0	2.5 (Naphthalene present)	..
225-250	..	19.0	2.0	7.5	..

No specific regularity in the percentage of unsaturated hydrocarbons in the various distillation cuts is to be noted. The bulk of the unsaturated hydrocarbon formation has taken place in the three cuts to 150 deg. C. The maximum formation of unsaturates occurred in fraction C in cuts to 95 deg. C., 95-120 deg. C., and 120-150 deg. C., indicating that this particular fraction formed the amylenes, hexylenes, and heptylenes to decylenes most readily. Fractions C, D and E formed upon thermalization unsaturated hydrocarbons in much higher percentage yields than the low boiling point fractions A and B. The percentage of unsaturates in

the gas with the exception of fraction A gave only a 2.3 per cent difference in the other four fractions—ranging around 40 per cent in value while fraction A gave 16.1 per cent of unsaturated hydrocarbons. Since the percentage of hydrogen decreased in fraction A from 40.2 to 13.5 in fraction E, and the unsaturates increased from A to B in the gas, and showed higher values in the distillation cuts in fractions C, D and E in comparison to A and B, with a maximum in the distillation cuts of fraction C, we have two added angles from which to judge the stability of the hydrocarbon fractions started with, that the most stable paraffin hydrocarbons under the conditions of the experiments are those boiling between 200 and 250 deg. C. having formulas from $C_{12}H_{24}$ to $C_{15}H_{32}$.

G. The percentage yield of the aromatics—benzene, toluene and xylene in the recovered oils

TABLE 12

Temperature, Deg. C.	A	B.	C.	D.	E.
of Fractions	to 150	150-200	200-250	150-200, Vacuum	200-250, Vacuum
Per cent by volume					
benzene	3.1	1.2	0.8	8.4	14.4
Toluene	1.3	3.8	1.0	2.8	10.0
Xylene	2.2	2.7	2.0	2.5	11.1

In the recovered oils the yields of benzene ranged from 0.8 to 14.4 per cent. The maximas occurred in the low and high boiling fractions and the minimum in the middle fraction. The toluene percentage ranged between 1.3 and 10, while xylene gave values from 2.2 to 11.1.

The formation of aromatic hydrocarbons is apparently independent of the paraffin hydrocarbons started with. Whether the paraffins are short chained with few isomers or long chained compounds with many isomers, they all apparently decompose, forming the ethylene series, smaller molecular weight paraffin and aromatic hydrocarbons.¹²

H. The percentage yield of the aromatics—benzene, toluene and xylene on the basis of oil used for production

TABLE 13

Temperature, Deg. C.	A	B.	C.	D.	E.
of fractions	to 150	150-200	200-250	150-200, Vacuum	200-250, Vacuum
Per cent by volume					
benzene	0.07	0.4	0.6	2.1	2.9
Toluene	0.02	1.1	1.1	0.7	2.0
Xylene	0.05	0.8	1.1	0.6	2.2

The percentage yields of the aromatic hydrocarbons, benzene, toluene and xylene, on the basis of oil used, emphasizes again the importance of the starting hydrocarbon oil in their production. There is, as illustrated by the above table, an increase from 0.07 to 2.9 per cent in the benzene yield, toluene varies between 0.02 and 2 per cent, and xylene between 0.05 to 2.2 per cent. These values are widely different and show that groups of the high boiling point paraffin hydrocarbons in the distillation cuts lend themselves more readily to aromatic formation than the low boiling point paraffins. This is directly in accord with theoretical considerations when one considers the long chain aliphatic hydrocarbons, with their many isomers, splitting up into a greater number of the ethylene series hydrocarbons and lower boiling point paraffins.¹³ The ethylene series hydrocarbons polymerize, readily forming naphthenes, which decompose to aromatic hydrocarbons.¹⁴

¹²Egloff, Met. and Chem. Eng., 16, 692, 1916.

¹³Haber, Jour. Gasbel., 39 (1896), 377, 395, 435, 452, 799, 813, 830.

¹⁴De Montmolin, Bull. Soc. Chim., 19, 242 (1916).

General Discussion

Hartogh¹⁵ has reported that by refluxing a sulphuric acid washed benzene having a distillation value of 91 per cent boiling below 105 deg. C. and a specific gravity of 0.698, that after several hours the analysis gave a much wider distillation range, and upon sulphuric acid treatment a 10 per cent of unsaturated hydrocarbon test.

Engler and Höfer¹⁶ state that this experiment is open to further verification, for they bring out the points as to how far the oxygen of the air or the catalytic effect of the copper vessel used in the distillation entered into giving the recorded results. Further doubt is thrown upon Hartogh's result by the work of later experimenters, who worked with a heavier Russian benzene of a specific gravity of 0.745 and 98 per cent boiling below 148 deg. C. in one case, and in the other a specific gravity of 0.732 and 95 per cent boiling to 130 deg. C. In both cases no appreciable decomposition of the starting oils was noted.

The criticism of Engler and Höfer is of interest, but even though the air or copper catalysed the reaction so as to give the results recorded by Hartogh of 10 per cent unsaturation after distillation, the results are highly significant. Although the decomposition took place by possible catalysers, the results are important when compared with those of the present communication.

It is certain that the viewpoint of the stability of paraffin hydrocarbons toward heat, decreasing with increasing molecular complexity, is no longer tenable from the experimental evidence presented. It is recognized that the behavior of the gaseous paraffin methane in comparison to the liquid paraffins shows marked stability toward heat. In particular methane persists longest in thermal decomposition of hydrocarbons, and is also the most stable of the paraffin hydrocarbons recorded in the literature.¹⁷

A study of the thermal decomposition of individual paraffin hydrocarbons under like conditions would show methane in all likelihood the most stable, with a decrease in stability as the molecular weight increased, to a minimum, and then a maximum would again be reached in one of the paraffins in the group boiling between 200 deg. and 250 deg. C., $C_{16}H_{34}$ to $C_{18}H_{38}$, with another minimum as the complexity of the molecule increased, and perhaps another maximum in a compound like $C_{20}H_{42}$, with the highest molecular weight paraffin hydrocarbon going to the ultimate products carbon and gas.

As to the theoretical considerations involved in the greater stability of the group of paraffins $C_{16}H_{34}$ to $C_{18}H_{38}$ in comparison to the relatively shorter chained compounds $C_{12}H_{26}$ to $C_{14}H_{30}$ information is lacking as to the heats of combustion, heats of formation, internal pressures and similar constants of the higher paraffin hydrocarbons, which would throw light upon the stability of paraffin hydrocarbons.

Conclusions

1. Five fractions of a paraffin-base petroleum oil with boiling points to 150 deg. C., 150-200 deg. C., 200-250 deg. C., and vacuum distilled from 150-200 deg. C. and

200-250 deg. C., have been thermolized at a temperature of 700 deg. C. with a view toward determining their stability at this temperature.

2. It has been established that the fraction boiling between 200-250 deg. C. paraffins with molecular weights between $C_{16}H_{34}$ and $C_{18}H_{38}$ is most stable under the conditions of the experiment.

3. The percentage of starting fraction recovered; to carbon and gas, differences in the specific gravity and refractive indices, volume of gas, per cent of benzene, toluene and xylene in the recovered oil, experimentally determined that the fraction with boiling point between 200-250 deg. C. are the most stable paraffins at 700 deg. C.

TABULATED EXPERIMENTAL RESULTS

	A	B	C	D	E
Distillation temperature of fractions, to 150°C	150-200	200-250	200-250	150-200 Vacuum	200-250 Vacuum
Per cent of recovered oil	2.3	29.3	66.7	25.0	20.0
Per cent to carbon and gas	97.7	70.7	33.3	75.0	80.0
Differences in specific gravity of original and thermolized fractions	0.053	0.027	0.008	0.047	0.120
Differences in refractive indices of original and thermolized fractions	0.03507	0.01805	0.00699	0.0173	0.03556
Liters of gas per liter of oil used	710.2	560.7	420.4	476.7	514.4
Per cent of benzene in recovered oil	3.1	1.2	0.8	8.4	14.4
Per cent toluene	1.3	3.8	1.0	2.8	10.0
Per cent xylene	2.2	2.7	2.0	2.5	11.1

4. It has been shown experimentally that the general belief, as exemplified by the statement, "It is well known that the simpler petroleum hydrocarbons are stable at much higher temperatures than those of higher molecular weight," is no longer tenable.

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Synopsis of Recent Metallurgical and Chemical Literature

Iron and Steel

Influence of the Time of Heating Before Quenching on that Operation.—ALBERT PORTEVIN, in an illustrated article of 52 pages, discusses the above mentioned subject in the January-February number of the *Revue de Métallurgie*, pp. 9 to 63. In the introduction to his paper, Portevin discusses in a general way, the state of cooling, the state of quenching, heating, the duration of constant temperature, the law of cooling and the interpretation of the results obtained. In the latter he states, that from the theoretical point of view, the effect on the electrical resistance must be considered, as, according to Benedicks, it is a means for quantitatively determining the elements in solid solution. Furthermore, from the practical point of view, most of the interest is based on the effects of heating on the mechanical properties of the material treated; and finally, that for all methods of investigation the micrographical study is of paramount importance.

Chapter I treats of the preliminary study of heating in fused salts. The subject is first covered in a general way, then methods for procedure are described, the latter comprising thermometric and calorimetric methods, and finally a study of the various fused salts used is given. The salts tested were potassium nitrate and nitrite, sodium chloride, potassium chloride, fused calcium chloride, hydrated barium chloride, hydrated strontium chloride and pure potassium chloride. The results obtained under varying temperature conditions

¹⁵Dissertation, Bonn, 1908. Also *Das Erdöl*, 495, vol. 1.

¹⁶*Das Erdöl*, 496, vol. 1.

¹⁷Mayer and Altmayer, *Berichte*, 40, 2134, 1907; Bone and Coward, *Jour. Chem. Soc.*, 93, 1975, 1908; *Ibid.*, 97, 1219, 1910. Bone and Jordan, *loc. cit.*, 71, 41, 1897. Berthelot, *Ann. Chim. Phys.*, 6, 189, 1905. Pring and Hutton, *Jour. Chem. Soc.*, 89, 1591, 1906. Pring and Fairlie, *Report 8th Int. Cong.*, 21, 65. Holgate, *J. Gas Lighting*, 106, 25, 84, 1909. Simmersbach, *Stahl u. Eisen*, 33, 239, 1913. Hollings and Cobb, *Gas World*, 60, 879, 1914. Whitaker and Alexander, *Jour. Ind. Eng. Chem.*, 7, 484, 1915; Lewes, *Jour. Chem. Soc.*, 61, 332, 1922; *Proc. Roy. Soc.*, 45, 90, 1894; *Ibid.*, 57, 394, 1895. Bone and Coward, *Jour. Chem. Soc.*, 93, 1197, 1908.

are illustrated by numerous curves. Full explanations accompany the curves.

From here on the subject is divided into two parts: First, the effect of the treatment on the mechanical properties and on the electrical resistance of the ordinary carbon steels, and second, the effect of the treatment on special steels. Under the latter head fall tests made on various samples of chromium, tungsten and molybdenum steels. All results, at every instant, are summarized either in tables or curves, or both. Analysis of samples tested are given, and many micro-photographs illustrate the various effects on the structure of the materials tested.

The conclusions drawn from the work are as follows: First, from the practical point of view the rate of transformation in steels is appreciable even at ordinary temperature, and increases with the temperature, and secondly, from the industrial point of view, the properties of a steel depend essentially on the length of time of heating before quenching. These results were obtained after jointly considering the changes in the mechanical properties, changes in electrical resistance, and the change of structure as examined by the microscope.

In an appendix to the same paper the author elaborates on the laws of heating, the calorimetric determination of the total duration of heating of small samples in an industrial gas furnace, the decarbonization of steels in salt baths, and the thermal determination of the intensity of quenching of steels. Like the main article, the appendix is illustrated by curves, tables and micro-photographs.

Copper

The Metallography of Copper.—Under the title, *The Study of Metallography, Internationale Zeitschrift für Metallographie*, VII., 124, 1915, M. V. SCHWARZ treats the metallography of copper. The article is elaborately illustrated and the conclusions drawn by the author are of more than common interest.

Especially of interest are the conclusions drawn on the formation of crystals of copper in the process of electrolysis. The most favorable conditions for the formation of crystals in this process are a low temperature and no agitation of the electrolyte. The cause of the formation of elongated crystals is a lack of diffusion. The disposition of the various crystalline grains may be recognized by the position of the lamellae. The author draws attention to the importance of corrosion figures in the microscopic examination of metals. In a microscopic slide the electrolytic crystals appear more brilliant than the surface of the cut which corresponds most exactly with one of the faces of the crystal.

The author claims to have observed the growth of these electrolytic crystals. He discards the idea of the influence of the grain size on the growth of the crystals, but ascribes the form of the crystal obtained to the aging process. This effect disappears on reheating. The "state of youth" of the crystal, as the author terms it, may be explained by aid of the kinetic theory and the law of mass action.

The elongated crystals form normally on the surface of separation. If, therefore, a copper wire is used as cathode, the crystals appear radially. A cut parallel to the surface of the electrode will then clearly show the copper crystallites. If the conditions of electrolysis are changed during operations, the crystals appear in layers. These layers are successive, but the orientation of the crystals remains unchanged. The electrolytic copper crystals are very susceptible to pressure, so on cutting a sample with a very thin saw one observes before reheating the formation of isolated grains which do not melt in the mass.

Another factor of importance is that the author does not approve of the amorphous theory, as an explanation of what occurs between adjacent crystals. The material between the crystals, according to Schwarz, is made up of crystalline copper, so finely crystallized that the individuals cannot be recognized. This mass he calls "cryptocrystallines." This mass is less stable towards chemical and heat action, than the actual crystals. The polished surface of a sample is explained as the sliding of an upper surface following the sliding surface of the mass proper. The surface on examination shows no tendency whatsoever of forming amorphous material.

Melting Aluminium Chips.—The Bureau of Mines has undertaken an investigation of this subject and published the results in Bulletin 108. The authors are H. W. GILLET and G. M. JAMES. The bulletin gives an account of experiments made to compare the recovery of metallic aluminium in melting down chips such as are obtained in the automobile factories in machining aluminium castings. As aluminium has sold at three times its normal price for the past year, and as a recovery of but 60 per cent of the metal in the chips is common, and a 90 per cent recovery is commercially possible, the preventable loss is of considerable magnitude. The bulletin discusses the causes of the high loss in the usual method of melting chips, and shows that the difficulty of getting the tiny globules of molten metal resulting from the fusion of the very fine chips, to coalesce, when covered with a skin of oxide and dirt, is apparently the main cause for low recoveries.

Two methods of melting can be successfully used to promote coalescence. In one method the chips are kept just above the fusion point and the globules made to coalesce by hand puddling, which breaks through the skin and makes the globules unite. In this method melting is best done in an iron pot heated by oil.

The other is by the use of a flux which dissolves off the skin of dirt and oxide, producing clean globules which can unite. The flux suggested is 85 per cent common salt, 15 per cent fluorspar, used in large amount (20 to 30 per cent of the weight of the chips) and mixed with the chips before charging. Much higher temperatures are required by this method than by the puddling method, so the iron pot furnace is not practicable and melting is best done in graphite crucibles or in a reverberatory furnace. The flux method does not require the constant hand puddling of the other.

Since the presence of dirt and oxide causes low recoveries, the necessity for care and cleanliness in the collection and storage of chips is emphasized. Chips wet with cutting compound will oxidize superficially on storage, but by drying the chips by centrifuging this can be prevented. Perfectly clean chips can be melted without much loss by either method, while very dirty chips cannot be handled by any method so as to give the high recoveries of clean chips, although the two methods mentioned gave better results on dirty chips than any other methods tried. Care and cleanliness in the collection of chips in the machine shop producing them will give chips from which a high percentage of metal can be recovered, with a corresponding increase in the value of the chips sold by the shop. As on an average 15 per cent of the weight of aluminium castings for automobiles is machined off as chips, the possible saving to the automobile manufacturer is much greater than the cost of replacing careful methods for sloppy methods in the collection of chips.

New Paper Process.—According to the Journal of the London Chamber of Commerce, a process for making paper pulp for newsprint out of Kaing grass, which grows wild in Burma, is a success and steps have been taken toward its manufacture.

Recent Chemical and Metallurgical Patents

Various Electric Furnaces

Electric Melting Furnace.—A revolving arc furnace to be used for melting alloys containing zinc, such as the various brasses, and German silver, or containing manganese, such as ferro-manganese, is patented by HORACE W. GILLET and JAMES M. LOHR, of Ithaca, N. Y. The furnace is also adapted to the melting and refining of steel. It is of the indirect arc type, the arc being maintained between the electrodes over the charge (the electrodes being horizontal), but no arc is maintained between the electrodes and the charge. In melting yellow brasses agitation has been found to reduce vaporization losses of zinc on pouring, and agitation is provided for in this furnace by rotation of the furnace. The electrodes revolve with the body of the furnace. (1,201,224-5, Oct. 10, 1916.)

Electric Arc Furnace.—An electric furnace in which it is possible to use either freely burning arcs, that is, arcs burning between the electrodes, or arcs burning between the electrodes and the furnace charge, is patented by CLAS W. HARRY W. ECKERMANN of Ljusne and IVAR RENNERFELT of Djursholm, Sweden. Freely burning arcs are stated to be an advantage when melting scrap and the like, in case the charge is non-conductive when cold, and when the chemical reaction in the charge causes a violent boiling and formation of slag, as when puddling pig iron. Arcs contacting with the charge may be of advantage for deoxidizing and desulphurizing when the charge has become melted and the boiling ceased.

By a suitable arrangement of electrodes and connecting cable switch a double-throw switch it is possible, according to this patent, to have the arcs burning either between the electrodes only or between the electrodes and the charge. The idea is illustrated in Fig. 1, which

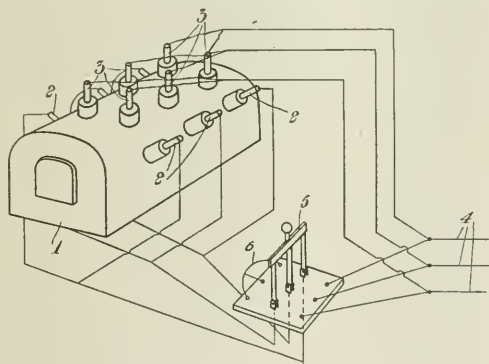


FIG. 1.—RENNERFELT ELECTRIC FURNACE WITH CONNECTIONS

shows a twelve-electrode three-phase system. With the switch in the present position the side electrodes are disconnected and the bath serves as a neutral point in a Y-connected system. When the switch is thrown to the left the result is a Y-connected system with the conductor 6 serving as a neutral point and arcs between electrodes only. With the switch thrown to the right the result is the same, but a delta connection results. (1,206,057, Nov. 28, 1916.)

Electric Furnace for Treating Gases.—An electric furnace having a rotating flame for treating gases is patented by IGNACY MOSCICKI of Lemberg, Austria-

Hungary. In electric furnaces in which the flame produced by an alternating current rotates under the influence of a magnetic field the reignition of the flame at the instant of reversal is troublesome and requires a relatively higher voltage. The present design attempts to overcome this difficulty by a specially designed conical shape electrode. The chief claim is:

"An electric furnace for the treatment of gases and vapors, in which furnace a high-tension, alternating-current flame rotates under the influence of a magnetic field of force, said furnace having an outer electrode within which is inclosed the reaction chamber; an inner electrode that projects therinto; a hollow ring which is detachably fastened to the outer electrode so as to be readily exchangeable and is provided with an ignition-edge inclined toward the inner electrode and is arranged for the passage of a cooling medium; the interval between said electrodes measured in the direction of flow of the gases increasing very rapidly; the inner electrode being arranged free to be shifted and to be adjusted relatively to the outer electrode in such manner that the ignition-ring remaining free between the electrodes can be adjusted exactly to the tension of the working current so as to be able first to generate the flame at said ring at every current reversal and then, under the influence of the powerful magnetic field and the great velocity of the gases, to draw the flame out to a great length and absolutely within a small fraction of the period of a single alternation." (1,201,607, Oct. 17, 1916.)

Induction Furnace.—An induction furnace for the melting of metals is patented by JAMES R. WYATT of Philadelphia, Pa., and assigned to the Ajax Metal Company, Inc., of Philadelphia, Pa. Stirring of the molten charge is accomplished by the motor effect of induced currents flowing in opposite direction close together and at an acute angle to each other. For details of the furnace the patent specification should be referred to. (1,201,671, Oct. 17, 1916.)

Nitric Acid

Nitrogen Fixation Furnace.—A new design of electric furnace for nitrogen fixation is patented by ERNEST K. SCOTT of Belvedere, England (assigned to Atmospheric Nitrates, Ltd., of Manchester, England). "The primary object of the invention is to increase the efficiency of such furnaces by insuring that practically all the air which enters the furnace passes through the arc. This object is attained according to this invention by the employment of electrodes so shaped and disposed that they inclose a central space, which is preferably in the form of an inverted cone, arcing gaps being provided between adjacent electrodes." (1,203,276, Oct. 31, 1916.)

Improvements in Birkeland-Eyde Furnace.—A method of bracing the electrodes in an electric arc furnace of the Birkeland-Eyde type is patented by CARL O. A. DÖVLE of Notodden, Norway. In the operation of electric arc furnaces with arcs moving along the electrodes, irregularities have occurred due to vibration. In the present patent these vibrations are eliminated by braces. (1,204,349, Nov. 7, 1916.)

Chemical Engineering

Separation of Oils.—Machine shops and garages accumulate from time to time certain quantities of waste oils and greases which have no commercial value, being mixtures of lubricating oils, burning oils, and gasoline. Mr. SIDNEY CORNELL proposes to separate the gasoline and more volatile oils from the heavier lubricating oils, greases, etc., by the following method: A closed retort is provided with two steam coils in the upper and lower part of the retort respectively so that

the upper and lower parts may be heated independently to desired temperatures. The oil mixture is fed into the retort so as to fill its lower half and is heated by means of the lower steam coil while at the same time saturated steam is blown into the oil mixture from below through a number of jet openings in the bottom of the retort. The steam passing through the oil mixture brings it into an emulsified or frothy condition. When the emulsion or froth comes in contact with the upper steam-heated coil above the liquid, separation of the gasoline, benzine, etc., from the emulsion takes place and these light volatile hydrocarbons, together with the remaining steam, distil over into a condenser, where they are condensed. The heavier lubricating oil remains back as residue in the bottom of the retort. (1,202,969, Oct. 31, 1916). [The process has been in operation in a large-scale experimental plant for some time in Long Island City, where we recently witnessed a successful test on separating gasoline from crude oil. As operated, it appeared that cracking plays a part in the process. It is stated that the process, the patent rights of which have been assigned to Mr. Richard Elkins, will be used in a plant in the Oklahoma oil field by the Intercoast Oil & Refining Company.—Editor.]

Aging Wine.—Dr. ARTHUR LACHMAN of San Francisco, well known by his charming little book on "The Spirit of Organic Chemistry," and equally well known by his more recent successful business activity in wine making, has patented a process for aging wine in which the wine is subjected to heat, pressure, and electric treatment; to save fuel and to make the operation continuous, the heat of the wine whose treatment has been completed is used to warm up the wine which is to be treated. A pressure of 5 to 25 lb. per square inch is satisfactory for sweet wines, with a temperature of 140 deg. Fahr. The electrical treatment consists of the passage of high-tension alternating current between electrodes in the treatment tank. The process produces in twenty-four hours aging results which otherwise require many months. (1,204,669, Nov. 14, 1916.)

Progress in the Use of Kieselguhr in the Insulation of Metallurgical Equipment

We have repeatedly referred in these columns to the very interesting and progressive work of the Kieselguhr Company of America, with principal offices in Los Angeles and New York, and with mines in Santa Barbara County, Cal., in adapting their kieselguhr products, "celite" and "silocel," to the solution of insulating problems for metallurgical equipment. Progress has especially been made in increasing thermal efficiency and producing greater uniformity of temperature, resulting in an increase of works' capacity and of uniformity of grade of product, together with better working conditions.

Hot-Metal Cars.—Recently, silocel insulating brick have been used for the insulation of hot-metal cars and metal mixers, giving a greater radius for these cars and an appreciably reduced loss through the formation of sculls, and almost entirely eliminating the chilling effect due to heat losses while in the car.

A 2-in. layer of silocel insulation as a backing for the refractory lining reduces the external temperature of the car to such an extent that the hand can be held on the outer shell with entire comfort.

Mains and Bustle Pipes.—The effect of insulating high-temperature mains, flues, and bustle pipes is primarily to give a greater capacity to the stove equipment and produce a more uniform blast temperature at the tuyeres. In one of the several installations in which a 4½-in. course of silocel insulating brick are

used as a backing for the lining of bustle pipes the variation in temperature on the far side of the bustle pipe was reduced by more than 50 deg., with a notable increase in the uniformity of the pig produced.

In the operation of waste-heat boilers the flue insulation is of vital importance.

Hot-Blast Stoves.—One of the most serious heat losses occurring in blast-furnace equipment is that through the sides and tops of hot-blast stoves. This effect, of course, is particularly noticeable in the cold weather, which, in certain cases, causes a complete shutdown of the stack, due to inability to obtain the proper blast temperature at the tuyeres. Within the past two years more than sixty hot-blast stoves have been completely insulated in sides and top with silocel products, many of which are now operating under unusually high thermal efficiency.

Crucible Furnaces.—One of the primary considerations in the operating of crucible furnaces is the difficulty in handling high temperatures encountered in this work. In the insulation, for instance, of the back of a crucible furnace with 2½ or 4 in. of insulation, a comfortable working condition is produced for the men, and at the same time it gives an appreciably more uniform furnace than can be obtained in any other manner. A number of crucible-steel furnaces have been insulated with both silocel insulating brick and powder, and are operating under unusually successful conditions.

This same factor, of course, applies to handling case-hardening and tempering furnaces, the majority of which are being insulated with silocel products.

Regenerators.—The insulation of regenerator and checkerwork settings for open-hearth furnaces, and other forms of equipment requiring pre-heated gases, produces increased thermal capacity and a higher average blast temperature, because of the elimination of the valleys and the peaks necessary to take care of the conduction losses in uninsulated equipment. In other words, the working temperature of the blast as it leaves the regenerator is more nearly a straight line in the case of insulated equipment than is possible in the ordinary form of regenerator, in which the heat losses by conduction are allowed to go on unchecked.

Insulation of Foundations.—Heretofore, little or no attempt has been made to check the heat losses from the bases and foundations of high-temperature equipment, although this has been found to be one of the most serious losses. This has been due to the effect that insulating materials of the proper structural strength have not been generally available for this character of work. With the introduction of silocel products, with very high insulating value combined with mechanical strength, this difficulty has been largely overcome, and many of the largest installations of heated equipment in the country are now having their bases, as well as the exposed parts entirely insulated.

By-product Coke Ovens.—The uniformity of interior temperature is of primary importance in the production of coke, either in by-product, beehive or gas generators, and, while the method of applying insulation varies in the different types of equipment, on account of the mechanical construction and the arrangement of the condensing equipment, the effect of insulation is to a large extent comparable to that in other forms of high-temperature equipment.

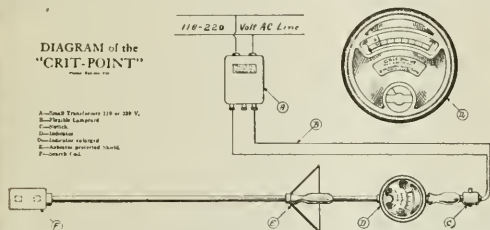
Gas Plants.—The modern coal-gas plant is now entirely insulated from the base to the top, especially the retorts, to give a higher yield of gas, more uniform operating temperatures, and a more uniform grade of coke than has been possible in the older types of equipment. Several of the largest plants in the country are

now completely insulated with silolac products and are producing at an unusually high thermal efficiency.

Oil Stills.—The application of insulation to the settings and mains in oil stills is rather recent, and the effect is very pronounced in the saving of fuel, etc.

The Critical Point in the Heat Treatment of Steel

In the heat treatment of steel it is all-important to know exactly when the critical temperature or the "critical point" is reached. In the "crit-point," a new instrument of the Gibb Instrument Company of Pittsburgh, Pa., use is made of the well-known fact that steel in the process of heating loses its magnetic properties when it is brought to its critical point. Through the medium of electromagnetic coils the magnetic condition of the steel in the furnace is determined. A magnetic indicator is placed in the circuit, so that



this meter immediately indicates whether the steel has reached its critical point. When the surface of the steel in time becomes non-magnetic, or in other words, the temperature of the surface comes up to the critical point, the meter needle approaches the red line indicative of the critical point and gradually comes nearer and nearer to it, as the heat penetrates the steel and the interior is brought to the critical point.

It will be seen that the "crit-point" does not measure temperature. But the exact knowledge of the temperature is irrelevant as long as the heat-treating man has a simple and exact means off hand for ascertaining when the critical temperature is reached.

Tests on a Die-Casting Copper Alloy

The following tests were made on samples of "Ampco" bronze, a 90 per cent copper-base alloy made by the American Metal Products Company of Milwaukee, Wis.

The name bronze is somewhat of a misnomer, as the alloy contains no zinc, tin, lead or phosphorus. It was developed to furnish a low-melting-point copper-base alloy for die casting which should have great strength. It is furnished in grades having a tensile strength of from 50,000 to 100,000 lb. per square inch elastic limit, 20,000 to 45,000, elongation 50 per cent to 4 per cent, reduction of area 28 per cent to 8 per cent and Brinell hardness 70 to 280.

TENSILE TEST OF THE MILWAUKEE ELECTRIC RAILWAY & LIGHT COMPANY

MATERIAL "AMPCO" BRONZE No. 11 A.C.

Received from the American Metal Products Company

Diameter	0.560
Area	0.246
Elastic limit	6,700
Elastic limit, square inches	27,230
Ultimate strength	16,210
Ultimate strength, square inches	65,890
Elongation, inches	25/32
Elongation, 2 in., per cent	39.1
Reduced diameter	0.450
Reduced area	0.159
Reduced area, per cent	35.4
Fracture	Irregular
Grain	Silky

TENSILE TEST OF ALLIS-CHALMERS MANUFACTURING COMPANY

MATERIAL "AMPCO" BRONZE No. 11 1/2

Original dimensions	0.505
Original area in square inches	2
Dimensions after fracture	1.520
Area after fracture, square inches	7,290
Elastic limit, pounds actual	16,900
Maximum load, pounds actual	49
Elongation in inches	36,450
Elastic limit per square inch	24.5
Tensile strength per square inch	24.0
Per cent elongation in inches	
Per cent reduction of area	

SOLUBILITY TESTS ON "AMPCO" BRONZE No. 16

MADE BY ELYRIA ENAMELED PRODUCTS CO.

Loss—Grams Cu. Cn.

Solution	Loss, Per Cent	24 Hrs. Cold	4 Hrs. Hot	Loss, Per Cent
Sulphuric acid	10%	.0001	.0002	.0004
Sulphuric acid	50%	.0001	.0001	.0004
Acetic acid	5%	.0002	.0002	.0001
Acetic acid	10%	.0001	.0001	.0001
Citric acid	5%	.0001	.0001	.0002
Citric acid	10%	.0002	.0002	.0002
Formic acid	10%	.0001	.0001	.0001
Phosphoric acid	10%	.0001	.0001	.0001
Sodium hydroxide	5%	.0001	.0001	.0001
Sodium hydroxide	10%	.0001	.0001	.0001
Phenol	Con.	.0000x	.0000x	.0000x
Lactic acid	10%	.0010	.0010	.0010
Tartaric acid	10%	.0021	.0021	.0021
Ammonium hydroxide	Con.	.0006	.0006	.0006
Ammonium hydroxide	28%	.0002	.0002	.0002

SULPHURIC ACID TEST MADE BY HAMMERMILL PAPER CO.

Before Test	After Test	Loss in Weight, Grams	Loss, Per Cent	Changes of Acid	Time Immersed, Days
27.7158	27.6916	.0242	0.09	20	32
26.4110	26.3917	.0193	0.07	13	30

New York Meeting of American Institute of Chemical Engineers

The winter meeting of the American Institute of Chemical Engineers will be held in New York City from Wednesday to Saturday, Jan. 10 to 13, 1917. All the business meetings and technical sessions will be held at the Chemists' Club. Excursions (for members only) have been arranged for the afternoon of Wednesday, the whole of Thursday, and the afternoon of Friday. A subscription dinner will be held on Thursday.

The following papers will be presented:

Wednesday, 11 a. m.:

- "Unpreparedness," President George D. Rosengarten.
- "Recent Developments in Chemical Engineering Equipment," H. D. Miles, president Buffalo Foundry & Machine Company.
- "Corrosion of Ingot Iron, Containing Cobalt, Nickel, or Copper," Prof. Herbert T. Kalmus and K. B. Blake, Queens University.

Wednesday, 8 p. m.:

- "The Human Side of the Development of Chemical Industries," G. W. Thompson, National Lead Co.
- "The Fixation of Nitrogen," Prof. John E. Bucher, Brown University.

Friday, 10 a. m.:

- "The Decatur Sewage Disposal Plant of the Electrolytic Sanitation Company," William Hoskins, Mariner & Hoskins.
- "The Effect of Centrifugal Force on Colloidal Solutions," E. E. Ayres, Jr., Sharples Specialty Co.
- "Recent Developments in the Absorption and Distillation of Volatile Liquids," Charles L. Campbell, E. B. Badger & Sons Company.

Friday, 8 p. m.:

- "Chemical Engineering Aspects of Renovating a Sulphide Mill," Hugh K. Moore, Berlin Mills Company.
- "Recovery of Benzol from Coke Oven and Illuminating Gas," C. J. Ramsburg, H. Koppers Company.

Personal

Dr. William Beckers of the Beckers Aniline and Chemical Co., Brooklyn, N. Y., addressed the American Association of Woolen and Worsted Manufacturers at its recent eleventh annual meeting in New York. The title of his paper was "Dyestuffs Progress in America and What Is to Be Expected in the Future; the Relation of the Manufacturer of Explosives to the Manufacture of Dyestuffs."

Mr. George A. Burrell, consulting chemist, Pittsburgh, Pa., lectured before the Franklin Institute of Philadelphia, Pa., on December 7th, on the technology of the natural gas gasoline industry.

Mr. Meyer Davis, formerly chief engineer, has been appointed manager of the San Francisco office of the Asbestos Protected Metal Company. The office is in the Hobart Building.

Mr. J. V. N. Dorr was presented with the John Scott Legacy Medal by the city of Philadelphia on the recommendation of the Franklin Institute, for his inventions along the line of metallurgical apparatus.

Dr. Sam Eyde, the well known joint inventor with Prof. Birkeland, of the nitrogen fixation process which is now operating successfully in Norway, passed the half century mark recently. The Scandinavian papers have given a summary of Dr. Eyde's accomplishments, and foremost of these is his active and successful work developing the nitrogen fixation industry in Norway. Three hundred thousand horsepower are operating at Rjukan on this industry alone and the net income of the company, of which Mr. Eyde is manager, was in the year of 1913, 25,000,000 kroner, or close to \$9,000,000. At the present time the daily production of this plant is five hundred tons of nitrates. Mr. Eyde made several large donations for various scientific and humanitarian purposes in commemoration of his anniversary.

Mr. Edwin Higgins has been elected as consulting engineer of the United States Bureau of Mines.

Mr. Theodore J. Hoover has opened an office in San Francisco in the Mills' building.

Mr. J. E. Johnson, Jr., consulting engineer of New York City, sailed on December 15 for China on professional business.

Mr. Frederick Laist is the new manager of the Washoe Reduction Works at Anaconda, Montana, in which capacity he succeeds E. P. Mathewson. C. A. Lemmer has been appointed assistant manager.

Mr. G. A. Marsh, superintendent of the Pueblo smelter of the A. S. & R. Co., was in Denver recently, on business.

Mr. Wm. Motherwell, flotation engineer, has returned to Nelson, B. C., and has entered consulting practice. Mr. Motherwell's experience began ten years ago at Broken Hill, Australia, and since that time he has had experience in Queensland, Arizona, Colorado and Mexico.

Professor W. A. Noyes, director of the chemical laboratory of the University of Illinois, will lecture on "the electron theory" before the Franklin Institute as part of the 1916-1917 program.

Mr. Raymond B. Price, vice-president of the United States Rubber Company recently returned to New York from a three months' trip to Europe. He was entertained at luncheon at the Technology Club on December 15, after which he gave a very interesting talk on recent developments in Europe as affecting American business now and after the war. He said that production has been speeded up enormously on all sides in Europe, and the lessons they have learned in efficiency in centralized control and in the rela-

tions between labor and capital are not going to be lost after the war but will be retained and utilized in industry.

Mr. A. K. Richards is now engineer and superintendent of construction of the Colorado Portland Cement Co. He was formerly with the American Vanadium Co., Mackintosh-Hemphill & Co., of Pittsburgh, and the Cambria Steel Co., Johnstown, Pa.

Mr. Charles H. Rosenthal, formerly with the Calco Chemical Company of Philadelphia is now chemist with the Benzol Products Company at Marcus Hook, Pa.

Mr. R. W. Schultz, who represents the Minerals Separation Company, Ltd., is at Houghton, Mich.

Mr. Joseph Stabel, of Buffalo, has been elected a director of the Inspiration Gold Mines, Ltd., Mr. Stabel has purchased a large interest in the company.

The Chemical Market in the United States in 1916

Coal Tar Products

Production during the year just closed of coal-tar crudes and intermediates has perhaps increased generally in greater proportion than any other department of the chemical industry. The vast work started in the early part of 1915 was successfully and on a broader scale carried on during 1916. Manufacturers of derivatives or coal-tar intermediates have increased in number and during the year practically all intermediates formerly produced in Germany and Switzerland were turned out here in varying quantities and with varying success. The result naturally has been a lowering of market values.

Broadly, these new companies have followed two widely diversified methods of operation. A majority has seemingly lacked the effort of concentration, with the result that a long line of intermediates were produced that as a rule lacked the proper degree of quality. These firms undermined their financial standing, with the result that a number of them passed out of existence, changed ownership or produced a line that promised a larger return. Capital generally was not lacking. The chief difficulties appear to have been the employment of inefficient talent, and the characteristically American effort to turn out a maximum amount in a minimum period resulting in an over-production, mainly of faulty products. New plants were, as a rule, hastily constructed. Apparatus manufacturers beset with raw material problems could not make timely deliveries. The cost of production was difficult to ascertain, and even at the date of writing intermediates are being sold at widely varying figures, reflecting the inability of some manufacturers to arrive at an accurate basis of their overhead.

On the other hand, there have been a number of manufacturers who have concentrated on a small line with the object of improving quality and disregarding quantity. These firms have without exception prospered. Their initial outputs perhaps were far from the standard established by the Germans, but with persistent effort continued improvement has been noted and to-day the American products rank with any produced abroad.

COAL-TAR CRUDES

The production of benzol has increased remarkably during 1916, and it is estimated that the total output is now no less than 30,000,000 gal. The number of American coke by-product plants with benzol recovery apparatus is sixty-one. The output for the most part has been absorbed by both manufacturers of intermediates

for dyes and for use in explosives. Exports during the early part of the year, particularly to England, were heavy, though within recent months buying by foreign countries has to an extent been curtailed, with the inevitable result that prices have been subject to a downward tendency. Benzol has now reached the average spot price of 57c. to 60c. per gallon, depending on quantity and individual view. This is a decline of 20c. to 23c. for the year. Contract business is to be had at from 54c. to 55c. However, most of the important producers have sold up a considerable portion of their output and are not now gunning for business.

Toluol has slowly but steadily declined from the high level of \$4.80 to \$5 a gallon, which prices were in evidence in the early spring of 1916, to the now prevailing price of \$1.80 to \$2 per gallon for immediate delivery and \$1.60 to \$1.75 for contracts covering delivery next year. On recent government business one large producer quoted \$1.50, and it is known that contracts have been awarded at somewhat less than this figure. The fact that one of the large producers under German ownership has refused to sell a product that would ultimately be used in manufacturing munitions for the Allies has caused a slightly more favorable market for domestic use than for export. Even at the present prices, however, a large margin of profit is shown the manufacturers. The 1916 production is estimated at 8,000,000 gal.

Xylol.—Commercial distilling 90 per cent at 160 deg. has remained comparatively steady at 35c. to 40c., though somewhat keener competition has induced manufacturers to modify their price levels somewhat. The output is small. Spot pure is quoted at \$1.20 to \$1.25; on contract \$1.

Naphthaline has been subject to considerable fluctuation, and from the high level of 17c. to 18c. that was paid for the prime white refined flakes late last winter, the low levels of 6½c. to 7c. were reached during the late summer and fall. Following the import duty of 15 per cent advalorem and 2c. per pound specific imposed recently on imported goods, the local market has strengthened considerably, and domestic manufacturers are quoting from 9c. to 10c., with the English goods held generally at from 10½c. to 11c. There are large surplus stocks available in England, but comparatively small quantities are now reaching this country. The United States production in 1916 is placed at 12,500 tons of refined.

Phenol has had an interesting history during the year, and price changes until recently have been frequent. So great was the demand both from abroad and for domestic account, for use in the manufacture of disinfectants, intermediates for dyes and for explosives, especially picric acid, that nearly twenty new plants started in operation. The increased output, however, combined with a curtailing of the wild demand, was instrumental in bringing prices to lower levels, and several of the new plants went out of existence. The present prices of from 53c. to 55c. show a moderately good profit, considering the cost of raw materials, and with some of the new manufacturers out of the market and a steady volume of demand in evidence, the market shows considerable steadiness, and not a few of the important producers have sold well up on contract. So far thirty-five plants have been equipped with phenol apparatus in this country. One of the operating companies' plant was disposed of at a receiver's sale and has been junked.

INTERMEDIATES

A short summary of the developments of the intermediates is extremely interesting. Chief among the benzol products is *aniline oil*. With the heavy produc-

tion of benzol at the outset of the year, and the big demand for dyestuffs and munitions, the output of aniline was greatly accelerated. Production, however, became excessive and a rapid and steady decline in prices was the attendant result. The average cost of manufacture, as computed by important manufacturers based on prevailing price of benzol and nitric acid, is from 26c. to 30c., and with the present price down to the low levels of from 23c. to 22c. of approximately 35 plants operating at the beginning of the year, all but 15 of them have been closed, and not a few have gone out of business altogether. The present price of aniline oil represents a decline of about 75c. for the 12 months, the year having opened at \$1. Definite figures of the American production of aniline oil are not available, but it is estimated that a year's output is now approximately 20,000 tons. As a result of high standards demanded of American manufacturers by aniline oil consumers at the beginning of the war, the quality of oil produced here has been higher than any previously marketed.

Aniline Salts.—This market has followed more or less closely the vicissitudes of the aniline oil market, and prices have dropped toward the end of the summer and since in proportion to the declines in oil. Compared with the consuming demand for salts, production has been more or less heavy, and as the year closes the prevailing price is from 28c. to 30c. for spot deliveries of hydrochloride.

Nitro Benzol (Oil of Myrbane).—Much of the domestic production of this benzol product was more or less unsatisfactory early in the year, as a considerable portion of the output of some factories had not been up to standard and many rejections were made. At present the outside market is dormant, with 16½c. to 17c. the prevailing price for the prime commercial, and up to 18c. for the refined.

Toluidine, the chief dye intermediate made directly from toluol, is being produced by perhaps half a dozen manufacturers with varying success. At the present time there are but two producers who are separating it into the para and ortho, and these only in a limited way, owing to the manufacturing difficulties encountered in the separating process. One large producer whose toluol is costing but a fraction of the ruling market price, is preparing to make the ortho and para.

Xylidine.—Due to the fact that supplies of xylol had not been particularly abundant, and the relatively small yield of the xylidine, production has not been particularly successful, and there are few manufacturers who have been able to turn out supplies in a commercial way.

Picric Acid was subject to wild speculation at the beginning of the war, but this subsided more or less during 1916. There were not the fabulous orders for foreign government nor the wild promises of manufacture that obtained earlier in the situation, and although there were some important orders placed for South American governments, as well as for the Allies, the business was well centered in comparatively few hands.

Trinitro-toluol was produced by but six large manufacturing concerns, and while the orders were not as heavy as in the preceding year, some large business has been placed, usually at somewhat lower levels. On recent United States ordnance department bids, the lowest proposed for the crude T.N.T. was 43c., and for the refined 63.5c.; both prices f.o.b. works.

Of the nitro compounds used in the manufacture of dyes, *paranitraniline* came in for most attention. Several manufacturers have within recent months started operations, but the majority of these are far behind in deliveries. This fact together with the heavy demand

both for domestic account and for export has kept the price at high levels. Supplies even now are scarce, and spot goods command from \$1.60 to \$1.70 per pound, with contract quoted at from \$1.15 to \$1.30, depending on seller and length of contract. Little interest, however, is now shown in future positions by consumers.

Dinitrotoluol is being made on a comparatively large scale, but manufacturers are chiefly using the product for their own consumption. Large explosive manufacturers are quoting at from 55c. to 60c. for important business.

Of the primary amines and derivatives, *alpha naphthylamine* commanded special attention. Large dye manufacturers have been using their output in their own processes, and independent manufacturers have at all times found a ready market for their supplies. Spot price ranged with moderate steadiness at \$1.25 per pound for immediate delivery, and from \$1 and up on contract.

Dimethyl aniline of the secondary amines and derivatives has been quiet, and prices have gradually been subject to declines, the prevailing levels being 55c. to 60c.

Diphenylamine.—The chief use for this has been as an explosive stabilizer, although some demand for use in dyes was noted. The production has been extremely limited, and important producers have sold up on contract.

Among the diamine group, *paraphenylamine diamine* has been subject to most demand, and the limited production keeps the price at the relatively high levels of from \$3.25 to \$3.75 for immediate deliveries.

Metaphenylene diamine production has been nominal, and the limited output has been rapidly absorbed by dye makers.

Metatolylene diamine is being produced in a few isolated cases by outside manufacturers, but by far the larger proportion of output has been by dye makers who consume their own product.

Betanaphthol has been produced on a large scale, and the number of manufacturers has been increased to about twenty. Heavy demand at the beginning of the year kept the price high at from \$1.75 to \$2 for the technical, and up to \$2.50 and \$2.75 for the sublimed, depending on seller and conditions of sale. The increased production, however, together with a lessening of demand, caused prices to drop to their present level of from 80c. to \$1.

The amido phenols and derivatives attracted considerable attention, particularly *H acid* (*amido naphthol disulphonic acid*), which is in keen demand, with restricted production owing to difficulties in manufacture. The two largest producers have and are using the product for their own consumption. Important foreign and domestic orders are unfilled, as supplies are not obtainable. Preparations are being made to turn out this product on a fairly large scale, and promises are made that the situation will be less tense in the future.

Salicylates have weakened gradually owing to over supplies and the prices have dropped from levels in the neighborhood of \$4 to the present prices of from \$1 to \$1.15, for both the *sodium* and *salicylic acid*. *Salol* has declined from the high level of \$9 in second hands to the prevailing price of \$2.25 to \$2.30.

DYESTUFFS

Activity during the year was confined to transactions in surplus German stocks and to an increased production of domestic colors.

Foreign Dyes.—Swiss and French colors were imported, but rarely reached the open market as ship-

ments to this country were invariably sold prior to arrival. While there has been no absolute scarcity as far as bulk is concerned of German colors during the year, prices have again ruled high, many hundred per cent above those prevailing before the war. With the possible exception of the alizarin colors, there was little difficulty noted in obtaining the various type productions at a price. Of the foreign colors, reds and blues, were at all times in brisk demand, but a good call was noted for a full line. Rhodamine B and 6G, eosine, fuchsine, Bismarck brown R and Y and primuline were colors mostly in demand during the latter part of the year. Prices toward the close of the year were lower than at any time since the beginning of the war. The two visits of the under-sea merchant vessel "Deutschland," carrying dyes and chemicals, came in for much public attention. The cargo on the first trip was much exaggerated. In tonnage it did not exceed three days' requirements of the entire American consuming industry. The colors, however, were concentrated, so that possibly the cargo represented four or five days' supplies for our textile and other color-consuming mills. No definite information has so far come to hand in regard to the bulk or the concentration of the "Deutschland's" second cargo. Unless a number of under-sea vessels are to engage regularly in this traffic, American color manufacturers do not look for very serious competition from this direction while the war lasts.

Domestic Dyes.—Blacks, of course, came in for most attention. A large number of concerns began the manufacture of sulphur black. Many difficulties were encountered, owing to inexperience and the difficulties of securing raw materials. Some very inferior color reached the market. Rejections, however, were seemingly the best development the trade had. It soon became evident that a good fast color must be produced or operations must cease, and good fast colors were turned out. A high percentage of the sulphur black produced to-day ranks well up with that of Continental Europe. Toward the end of the year one of the large explosive manufacturers not heretofore manufacturing colors began the delivery of this color. Other colors will shortly be marketed. Direct black, from a market viewpoint, probably attracted more attention than any other color during the year. Domestic manufacturers could not turn out sufficient material to answer the requirements of the trade and sales of a well-known brand were made above the \$2 level. Two and one-half years after the outbreak of the European war finds the American dye maker turning out practically a full line of aniline colors, with a few manufacturers producing from an anthracene base and vast experimental work progressing on all lines. The government census of dyestuffs came as an invaluable aid to the manufacturer here, who had been working entirely in the dark. There was no method of ascertaining the consumption of any one intermediate or color. The census allowed of a vast amount of analytical work. For example, orange II (sodium salt of p-sulphobenzol-azo-beta-naphthol), a popular color, not difficult to manufacture, is now selling for approximately \$3, prompt delivery. For contracts domestic manufacturers quote \$1. The imports of this color for the 1913-1914 fiscal year were 127,550 lb., valued at \$10,116. This is an average of \$0.079 per pound. It should be borne in mind, however, this price is net in bulk at German shipping point, does not include duty, containers, transportation or other incidental charges. Under the new tariff, effective at the close of the war, this color as well as all others will be protected by only a 35 per cent duty. Exports of domestic dyes and dyestuffs reached an amazing proportion. For the nine months ending September a

total outward business of some \$5,265,000 had been transacted. These colors went to practically every neutral country and the states of the Entente. Doubts are expressed as to whether American exporters can maintain this trade after the end of the war.

Heavy Chemicals

The output of practically every product in this classification during 1916 was the heaviest in the history of the industry.

Potassium Salts.—As compared with 1915, the past year was a comparatively tame one, in regard to the sale of surplus stocks of German potash. Supplies had dwindled to such small proportions that large transactions were no longer possible. For such small quantities of "muriate" as have been available up to \$500 had been paid, with a recession in price toward the end of the year. Some attention is now being given to the Japanese product, which is to be had at considerably lower prices. Sales, however, have been principally confined to chemical manufacturers of potassium salts. The search for potash within the United States has so far resulted in a production from kelp, cement, alunite, feldspar, and from natural deposits, of 45 tons daily of K_2O . One-half, or possibly more, is produced from the natural deposits of the Nebraska lakes. A production of 45 tons per day is about 6 per cent of the average daily consumption of K_2O in normal times.

Ammonium Salts.—Although no definite figures are yet available, the production of *ammonium sulphate* was unquestionably the largest in the history of the American industry, as a larger number of by-product coke plants were operated than ever before, and supplies of British sulphate were cut off, owing to the governmental embargo. Of the other ammonium salts, *nitrate* came in for a vast amount of prominence, for the manufacture of high explosives. The seven or eight American producers for the first six months of the year had considerable difficulty in fulfilling contract requirements. In the early fall there was a lull in the situation, with declining prices, but subsequently a sharp recovery was noted. At the present time exports, particularly to France and Italy, are exceedingly heavy, and large factors are quoting higher prices for contract than the prevailing spot figures.

Nitrate of Soda.—For the first time in the history of the industry the imports of nitrate of soda from Chili exceeded the million-ton mark. Prices ruled on high levels, opening the year at \$3.25 per cwt., and closing at near \$3.40. Sulphate of ammonia and nitrate of soda usually compete on a basis of unit of ammonium content, but owing to abnormal conditions prevailing, supplies of the sulphate were limited, and this situation did not exist during 1916 to any considerable extent.

Mineral Acids.—As the imports of sulphur ore (pyrites) for the nine months ending September, 1916, were in excess of the million-ton mark, it is quite safe to assume that the production of *pyrites Sulphuric acid* was again greater than the high-water mark of the previous year. The domestic and Canadian production of pyrites was also reported to have been larger than for any corresponding period. Brimstone acid has been subject to a heavier demand than ever before for use in explosives, and also in the manufacture of dyes. Early in the year prices ruled at high levels, but as production increased there was a let-up in the keen demand, and slowly but surely the price levels receded. For the last few months, however, there has been increasing call for the acid, and at the present time there is an actual scarcity; many important manufacturers are not taking business for prompt

delivery at this time, having well sold up on contract. There has been much complaint regarding the poor quality of the pyrites acid produced in the South. Acid prices have varied considerably, depending largely on location of plant. Northern producers are quoting from \$26 to \$28 per ton for the 66-deg. brimstone, and from \$16 to \$18 per ton for the 60-deg. brimstone. Pyrites acid is held at high levels, and Southern manufacturers are asking up to \$18 and \$20 per ton for the 66-deg. grade, f.o.b. plant. The price for the 60-deg. pyrites ranges from \$12 to \$15 per ton at works.

Muriatic Acid.—Demand for this acid has been spasmodic, although there has not been the recent advances that obtained in the sulphuric market. Some big orders have been placed lately, however, especially for contract. The 20-deg. goods are quoted at from 1½c. to 1½c., and up to 1½c. and 1¾c. for the 22 deg.

Nitric Acid.—Early in the year there was heavy demand in evidence, but since the late summer prices have gradually eased off, owing to the fact that production had increased, without the corresponding expansion of demand. The condition has improved during the last month, however, in sympathy with the changed sulphuric situation, and at present the 42-deg. grade is quoted at about 6c., and the lower concentrations at proportionately lower prices. Owing to the dangerous quality of the higher strengths, but few manufacturers are willing to concentrate above the 42-deg. mark, and prices on these grades rule high.

Organic Acids.—Acetic acid, glacial, started off in January, 1916, at about 30c. to 32c., and after some fluctuation, followed by gradual declines last spring, the low mark of 15c. was reached in October, when a complete metamorphosis occurred in the situation, and almost over night in the middle of November the price jumped to 30c., and has advanced to the present price of from 33c. to 35c. Heavy export demand, coupled with the starting of a strike at the plant of one of the largest producers, created the change. The 80 per cent grade is in heavy demand and has increased from the price of 7½c. to 8c. prevailing in November to the present figures of 14c. for the commercial, 16c. for the redistilled, and up to 17c. for the pure. The lower strengths advanced in sympathy, although little demand is in evidence.

Lactic Acid.—The market continues rather steady, at 5c. to 5¼c. for the pale 22-deg. rectified.

Phosphoric Acid.—Supplies are nominal, and have been for some time; the few domestic producers are well sold up into the future, and but limited supplies of the 47 to 50 per cent liquid are to be had at 13c. to 14c.

Oxalic Acid.—Steady imports from Norway and Holland, added to the increased domestic production, have caused an oversupply on the market, and following gradual declines the prevailing prices to-day range from 43c. to 48c., depending on grade.

Cyanides.—The fact that the electrical power of the only large producer of cyanides in America was curtailed recently has caused a wildly speculative market, with attendant soaring prices. From the price of 25c. to 30c. for sodium prevailing at the outset of the year, gradual advances obtained, until within the last three weeks prices jumped from 80c. to the abnormal figures of \$1.75 and \$1.80. The potassium is even higher in price, and sales were recorded just prior to the holidays at \$2.05 per pound. The demand is still heavy for mining operations, and supplies are nominal.

Chromium Salts.—These chemicals have had most particularly interesting careers during 1916. At the beginning of the year potassium bichromate was held at 45c., and increased gradually until in the spring the high levels of 90c. to 92c. for potassium and 65c. to

68c. for sodium were reached. During this time there was keen speculation in evidence, and manufacturers were having difficulty in filling orders. However, realizing the abnormal condition of the market and susceptibility to influences, manipulation began, in order to purchase resale supplies that they might be turned at a profit on orders. The market weakened under this pressure and gradually was reduced to the levels that now prevail, viz., from 40c. to 42c. for potash. Supplies which never were abundant are at this time scarce, and held with some firmness.

The present market in bichromate of soda is uncertain. The lowest figures that have obtained at any time during the year prevail. From 19c. to 20c. are the prices to-day. At the start of the year the price was 25c., which increased under heavy speculative demand to abnormal levels in the spring, receding gradually throughout the year to the present levels. One of the largest consumers in the country is now making its own chromium salt. Consumers generally had well contracted for their supplies. A Canadian owned production now competes with domestic manufacture. The general output has increased to a marked degree. The skillful manipulation has brought prices to their present levels. So great was the speculation during the high levels that many small buyers were caught, and heavy losses were incurred.

Copper Sulphate.—There has been a moderately strong demand all during the year, with high prices ruling, particularly during March and April. The output of the three largest producers is well sold up, and supplies in second hands are now more or less moderately small. Anticipated orders from abroad, however, especially from Greece, for use in spraying vineyards, not having materialized, the market is somewhat easier at present, and the large 98 to 99 per cent crystals are available at from 12c. to 12½c.

Alkalis.—Caustic soda, of course, has been traded in to an enormous extent, and the consuming demand has been on a large scale all during the year; this has been a highly speculative article, and gambling interests have played an important part in the price movements. Prices ranged from 5½c. to 5¾c. in January, 1916, to 6¾c. and 6¾c. in March, to the levels of 4.35 to 4.45 that now obtain. The fact that three new manufacturers have entered or are about to enter the field is also an important factor in bringing about the present prices. Contract business is almost at a standstill compared to usual activity. Producers are standing "pat" in an endeavor to keep the prices up.

Soda Ash.—Following the recent peace rumors, the market has receded somewhat, although as much of the large manufacturers' supplies are under contract; there is no pressing of stocks for sale. The spot price ranges from \$3.05 to \$3.10 for the 58 per cent light, flat basis, and on contract over 1917 at from \$2.65 to \$2.70. Some sales were made several weeks ago for 1918, but consumers are not booking business now so far into the future. At least two large important new producers entered the field.

Bleaching Powders.—The market for the last several months has shown steady declines from the high prices that were in evidence at the beginning of the year, which opened at 14c. to 15c. The difficulty of securing adequate supplies of drums suitable for export has increased perceptibly as time advanced. The spot price for bleach in large domestic drums is now 4½c., and for good export drums from 6¾c. to 6¾c., showing a difference of a full 2c. per pound for the different packing. Export demand is rather spotty, but generally heavy, Scandinavia and England, particularly, buy-

ing in large quantities for their paper and pulp mills. The present manufacture of bleach in this country has been fairly well contracted for by consumers and dealers, and supplies offered on the open market are therefore limited. The production of bleaching material by consumers for their own use increased as never heretofore.

CURRENT MARKET REPORTS

The Iron and Steel Market

The second half of December witnessed a sudden and marked slowing down in the iron and steel markets. Production continued at the fullest rate, except as curtailed by insufficient transportation facilities, many furnaces being banked through coke being slow en route, or through coke operators not having cars into which they could draw their ovens. Apparently the slowing down started with the German peace overture, which became public news on December 12, but there had previously been predictions that steel bookings would be much lighter in December than they had been in November, when the Steel Corporation's unfilled tonnage increased by a million tons only for the third time in the corporation's history. The advent of the holidays always slows down market activity, and thus there has been a combination of circumstances.

The iron and steel producers are little concerned with the market, their chief concern being the filling of the orders already on books, as there is prospect of a railroad blockade throughout the winter as severe, possibly more severe, than that of 1902-3, which railroad men pointed out at the time was the first in the history of American railroading, and might prove to be the last.

The common complaint is "car shortage," that being what the shipper experiences. It cannot be admitted, however, that there are fewer cars in the country than would be needed to carry the freight if they were loaded approximately to capacity and if they were kept in service. There has been no general increase in the minimum load for iron and steel products in about 17 years, practically the life of the steel-car industry. During that period the railroads have spent enormous sums replacing cars of small capacity with cars of greater capacity, but in many instances use is not made of the increased capacity. Consignees have been using cars for storage purposes, unloading their goods when they were ready, as \$1 a day for warehouse facilities, paid for when needed, and costing nothing when not used, proved a small expense. The demurrage rates were greatly increased Dec. 15, and this may help. The railroads are certainly short of motive power, and the inadequacy of motive power was particularly great when cold weather arrived, as locomotives that were able to get along in mild weather played out completely in cold weather.

Early in December a proposition was made that the iron and steel industry should shut up shop for a week or ten days to allow the railroads to clear their lines. The industry had no machinery even for adopting such a program, much less for carrying it out, while the desire probably was lacking owing to natural doubt as to the efficacy of a remedy never before tried. As car shortages have proved most serious in the Connellsville coke region, an automatic slowing down is probably in process. Beginning the week before Christmas, a number of furnaces were banked, and the number has increased steadily since then. Some of the steel works, however, have moderate stocks of pig iron, but the use of cold iron itself slows down production a trifle.

PIG IRON

A few advances in pig iron, practically negligible, have occurred since last report. The market is substantially at a standstill, with producers almost fully sold for the first half of 1917, and with very considerable tonnages on their books for the second half. As prices are easily the highest since 1880, and the excitement is over, a quiet market is to be expected for some time, except for the buying of some descriptions of pig iron in small lots for prompt shipment at a premium.

UNFINISHED STEEL

Unfinished steel has advanced about \$5 a ton since last report. Market prices are made by occasional sales, sometimes merely by bids. The buying demand has been narrow, but the offerings have been still scantier. Ordinary soft-steel billets and sheet bars are now quoted at \$60 to \$65, Pittsburgh or Valley, the lower price being readily bid for export, while it appears that the higher price has been paid occasionally for prompt lots. Wire rods command \$75 to \$80, the higher price having been paid on a round lot for export to Canada. Why wire rods should bring so much more than the billets from which they are made and the wire products they are customarily made into is not readily explained. At \$75 per gross ton, wire rods are 3.35c. per pound, or more than the base price of either plain wire or nails. Forging billets are quoted at \$80 to \$85.

FINISHED STEEL

The sheet market has continued to stiffen, and while prices for late deliveries may not be quotably higher, it is certain that higher prices are obtained for early deliveries than a fortnight ago. Otherwise, the finished-steel market is substantially unchanged as to prices, except for the advance of \$2 a ton in bars, shapes and plates, to 3c., 3.10c., and 3.60c. respectively, which occurred about Dec. 20. This advance, however, can hardly be viewed in the same light as the various advances that preceded it. They occurred, except perhaps as to certain advances early last August, when the buying pressure was extremely heavy, while this advance occurred when the market had been distinctly quiet for a week. Students of steel market history will perhaps feel the atmosphere of old times, for at the end of a general price-advancing movement there has usually been a last advance which served to "clinch" or make sound the business placed on books at the next lower prices.

IRON ORE

December shipments of Lake Superior iron ore down the lakes were unprecedentedly heavy, amounting to 1,085,900 tons, and bringing the season total by lake to 64,734,193 tons. As more than 1,500,000 tons was doubtless moved by all-rail routes, the total shipments of the Lake Superior region, on the American side, must have exceeded 66,000,000 tons, against 47,000,000 tons in 1915, and 50,000,000 tons in 1913, the record year. There is no possibility, therefore, of there being a scarcity of iron ore in the winter or spring, fears as to which were expressed last spring. It is coke and limestone that are giving the blast furnaces their anxious time.

Non-Ferrous Metal Market

Dec. 26.—The chief factor influencing the market during the past two weeks has been the peace talk, and while some of the metals, especially lead and tin, have remained firm, buying has been curtailed to a great extent. The holiday season also had its effect, as buying is normally dull during the last two weeks of the year. The drop in the stock market did not have such a

great effect on the copper market as was anticipated, owing to the sold-up condition, but it did have the effect of inducing some consumers to sell surplus stocks which they had on hand.

Copper.—Since Dec. 11, on which day copper reached its highest point of 36c. for prompt electrolytic, the price has dropped, and electrolytic and Lake are now quoted at 31c. to 32c. for prompt delivery. New copper restrictions were put in effect in England, allowing no one to buy outside the United Kingdom without a permit, and the use of copper is forbidden except for government work. Business has been dull, with the exception of some reselling by consumers. Buyers are holding off until next year, and producers are believed to be pretty well sold up for the biggest part of next year, making it difficult to see how prices can go very low for some time to come. Exports up to Dec. 22 were 17,763 long tons.

Tin.—Straits tin has declined from 43.50c. on Dec. 11 to 40.50c. on Dec. 22. The London market has also declined considerably during the last two weeks, and £185 is quoted for prompt Standard and Straits. Insurance rates on shipments are higher, and arrivals continue to be light. As in the case of the other metals, the peace talk and the holidays have curbed buying. Several hundred tons of Banca tin arrived Dec. 21, and was offered at 40.50c., which is the present spot quotation for Straits.

Lead.—The lead market has remained strong in spite of the peace talk, and no January or February lead at the trust price of 7.50c. is to be had. Independents have cut their prices slightly from 7.75c. to 8c., down to 7.50c. to 7.62½c.

Spelter.—The peace talk stopped trading in the spelter market, and prompt spelter has declined from 12.30c. on Dec. 11 to 10.95c. on Dec. 22. Buyers are holding off, awaiting developments. Zinc-ore prices are lower, and producers showed more disposition to sell on Dec. 22, resulting in a small amount of business at lower prices.

Other Metals.—Antimony remains unchanged in price at 14.37½c. for Japanese and Chinese. The market has been dull. Aluminum is quoted at 60c. to 64c. for No. 1 virgin metal. Magnesium remains at \$3.50 per pound, electrolytic nickel at 50c., and cadmium at \$1.50. Platinum is quoted at \$99 per ounce, tungsten ore at \$17.50 to \$20.00 per unit, and silver at 75½c.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET DECEMBER 7.

Acetone, drums,	lb.	22½	23
Acid, acetic, 25 per cent,	100 lb.	3.50	3.65
Acetic, 50 per cent,	100 lb.	7.00	7.15
Acetic, glacial, 99½ per cent, carboys	lb.	.25	.30
Boric, crystals,	lb.	12½	13½
Citric, crystals,	lb.	.65	.67
Hydrochloric, commercial, 18 deg.	lb.	.01½	.02
Hydrochloric, 20 deg.	lb.	.02	.02½
Hydrochloric, 30 per cent, in barrels	lb.	.02½	.02½
Hydrofluoric, 50 per cent, in barrels	lb.	.05	.05½
Lactic, 44 per cent,	lb.	.14	.15
Lactic, 22 per cent,	lb.	.07	.07½
Nitric, 36 deg.	lb.	.06½	.06½
Nitric, 42 deg.	lb.	.07	.07½
Oxalic, crystals,	lb.	.47	.50
Phosphoric, 85 per cent,	lb.	.29½	.30
Picric,	lb.	.75	.85
Pyrazolic, resublimed,	lb.	3.25	3.45
Sulphuric, 60 deg.	lb.	.01½	.01½
Sulphuric, 60 deg.	lb.	.01½	.02
Sulphuric, oleum (Fuming), tank car-	lb.	.02	.02½
Tannic, U. S. P. bulk,	lb.	.90	1.05
Tartaric, crystals,	lb.	.60	.68
Alcohol, grain, 188 proof	gal.	2.70	2.72
Alcohol, Wood, 95 per cent,	gal.	.90	.92
Alcohol, Dehydrated, 180 proof,	gal.	.64	.65
Alum, ammonia lump,	lb.	.04	.04½
Alum, chrome,	lb.	.25	.26
Alum, potash lump,	lb.	.05½	.08
Aluminum sulphate, technical	lb.	.03½	.04
Aluminum sulphate, iron free	lb.	.05	.05½
Ammonia aqua, 26 deg. carboys	lb.	.06	.06½
Ammonia, anhydrous,	lb.	.25	.26
Ammonium carbonate,	lb.	.11	.12
Ammonium, nitrate	lb.	.12½	..
Ammonium sulphate, domestic	lb.	.04½	..
Amyl acetate,	gal.	4.50	4.75

Antimony salt, 75 per cent				Crucal, U. S. P.	lb.	.19	—	.21
Antimony salt, 65 per cent				Cresylic acid, refined No. 5	lb.	.18	—	.20
Antimony salt, 47 per cent								
Argols	lb.	.08	.09					
Arsenic, white	lb.	.074	.084					
Arsenic, red	lb.	.65	.70					
Barium chloride	lb.	.03	.034					
Barium sulphate (Blanc fixe) powder	lb.	.014	.05					
Barium nitrate	lb.	.15	.16					
Barium peroxide	lb.	.38						
Bleaching powder, 35 per cent	lb.	.014	.064					
Blox, crystals, sacks	lb.	.064	.07					
Brimstone, crude	ton	28.50	29.00					
Bromine, technical	lb.	1.40						
Calcium acetate, crude	lb.	.034						
Calcium carbide	ton	73.00	75.00					
Calcium chloride, 70-75 per cent, fused, lump	ton	23.00	26.00					
Calcium chloride, granulated								
Calcium peroxide	lb.	1.50						
Calcium sulphate	lb.	.10	.22					
Calcium phosphate	lb.	.30						
Carbon bisulphide	lb.	.054	.064					
Carbon tetrachloride, drums	lb.	.164	.17					
Caustic potash	lb.	.78	.90					
Caustic soda, 76 per cent	lb.	.044	.05					
Chlorine, liquid	lb.	.15	.24					
Copperas	100 lb.	1.25	1.50					
Copper carbonate	lb.	.45						
Copper chloride (cupric)	lb.	.55	.60					
Copper cyanide	lb.	.70						
Copper sulphate	lb.	.14						
Cream of tartar, crystals	lb.	.394	.41					
Crimo salt bags	100 lb.	1.75	2.00					
Formaldehyde, 40 per cent	lb.	.12	.124					
Glauber's salt	100 lb.	.75	.85					
Glycerine, bulk	lb.	.55	.56					
Hydrogen peroxide, gross	lb.	6.50	18.00					
Iodine, resublimed	lb.	4.25	4.30					
Iron oxide	lb.	.13	.15					
Iron sulphide	lb.	.04	.05					
Lead acetate, white crystals	lb.	.13						
Lead arsenate	lb.	.08	.09					
Lead nitrate	lb.	.154	.16					
Litharge, American	lb.	.094						
Lithium carbonate	lb.	1.02	1.05					
Manganese dioxide	lb.	.70	.75					
Maoganese borate	lb.	.36	.39					
Manganese chloride	lb.							
Manganese sulphate	lb.							
Magnesium carbonate, tech	lb.	.13	.14					
Nickel salt, single	lb.	.14						
Nickel salt, double	lb.	.114						
Phosphorus, red	lb.	1.00						
Phosphorus, yellow	lb.	.80						
Potassium bichromate	lb.	.42	.424					
Potassium bromide granular	lb.	1.35						
Potassium carbonate calcined, 80-85 per cent	lb.	.38	.40					
Potassium chlorate, crystals	lb.	.67	.70					
Potassium cyanide, 98-99 per cent	lb.							
Potassium iodide	lb.	3.40	Nominal					
Potassium nitrate	ton	450.00	460.00					
Potassium permanganate	lb.	.32	.33					
Potassium prussiate, red	lb.	3.00	3.50					
Potassium prussiate, yellow	lb.	2.50	2.75					
Potassium sulphate, 90-95 p. c., basis 80 p. c.	ton	275.00	300.00					
Rochelle salts	lb.	.34						
Sal ammoniac, gray, gran	lb.	.10	.15					
Sal ammoniac, white, gran	lb.	.174	.20					
Sal soda	100 lb.	1.10	1.25					
Salt cake	100 lb.	.75						
Silver cyanide	lb.	.70	.71					
Silver nitrate	oz.	.474	.494					
Soda ash, 58 per cent, light, flat	lb.	.03	.034					
Soda ash, 58 per cent, dense, flat	lb.	.034	.04					
Sodium acetate	lb.	.14						
Sodium benzoate	lb.	8.25	8.75					
Sodium bicarbonate, domestic	100 lb.	1.75	1.90					
Sodium bicarbonate, English	lb.	.03	.034					
Sodium bichromate	lb.	.24	.22					
Sodium bisulphite, powd.	lb.	.054	.06					
Sodium chloride	lb.	.28	.30					
Sodium cyanide	lb.	.28	.70					
Sodium fluoride, commercial	lb.							
Sodium hyposulphite	lb.	.014	.024					
Sodium nitrate, refined	lb.	.31	.35					
Sodium nitrate	lb.	.18	.20					
Sodium peroxide	lb.							
Sodium phosphate	lb.	.05	.06					
Sodium prussiate	lb.	.34	.36					
Sodium silicate, liquid	100 lb.	.85	1.00					
Sodium sulphide, 30 per cent crystals	lb.	.024						
Sodium sulphite								
Strontium nitrate	lb.	.28	.30					
Sulphur chloride	lb.							
Sulphur, flowers, sublimed	100 lb.	2.50	2.70					
Sulphur, roll	100 lb.	1.95	2.25					
Sulphur, crude	ton	29.50						
Tin bichloride, 50 deg	lb.	.15	.154					
Tin oxide	lb.	.48	.50					
Zinc carbonate	lb.	.25	.27					
Zinc chloride	lb.	.104	.114					
Zinc cyanide	lb.	.40						
Zinc dust	lb.	.24	.30					
Zinc oxide, American process	lb.	.094	.097					
Zinc sulphate	lb.	.074	.08					

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.60	.65
Benzol, 90 per cent	gal.	.60	.65
Toluol, pure, water white	gal.	1.75	2.25
Xylol, pure, water white	gal.	1.00	1.20
Solvent naphtha, water white	gal.	.25	.35
Solvent naphtha, crude heavy	gal.	.20	.22
Cresote oil	gal.	.12	.15
Dip oil	gal.	.30	.34
Pitch, various grades	ton	14.00	16.00
Carbolic acid, crude, 95 per cent	lb.	.95	1.05
Carbolic acid, crude, 50 per cent	lb.	.45	.70
Carbolic acid, crude, 25 per cent	lb.	.30	.34

Intermediates, Etc.

Alpha naphthylamine	lb.	—	1.25
Aniline oil	lb.	.23	.26
Aniline salts	lb.	.35	.38
Anthracene, 80 per cent	lb.	—	.10
Benzaldehyde	lb.	1.90	5.25
Benzene	lb.	—	8.00
Beta naphthol	lb.	—	1.15
Dichlor benzol	lb.	—	.58
Dimethylaniline	lb.	—	1.00
Diphenylamine	lb.	—	2.25
Fluoride	lb.	—	1.75
Monophenylendiamine	lb.	—	.33
Naphthalene	lb.	.60	.10
Naphthionic acid, refined	lb.	2.25	—
Naphthionic acid, crude	lb.	1.05	—
Ortho-anilinephenol	lb.	—	—
Ortho-toluidine	lb.	1.75	—
Para-amidophenol	lb.	8.00	8.50
Paranitraniline	lb.	—	4.00
Paraphenylendiamine	lb.	2.25	—
Para-toluidine	lb.	.53	.55
Phenol, U. S. P.	lb.	—	—
Resorcin, technical	lb.	25.00	26.00
Salicylic acid	lb.	1.00	1.15
Sulol	lb.	2.30	2.40
Sulphanilic acid	lb.	—	2.00
Toluidine-nixture	lb.	—	—

Petroleum Oils

CRUDE (AT THE WELLS)

Pennsylvania	bbl.	2.75	—
Corning, Ohio	bbl.	2.20	—
Somerset, Ky.	bbl.	2.10	—
Wooster, Ohio	bbl.	1.75	—
Indiana	bbl.	1.38	—
Illinois	bbl.	1.67	—
Oklahoma and Kansas	bbl.	1.20	—
Caddo, La., light	bbl.	1.20	—
Corsicana, Tex., light	bbl.	1.10	—
California	bbl.	.74	—

LUBRICANTS

Black, reduced, 29 gravity, 25-30 cold test	gal.	.134	.14
Cylinder, light	gal.	.18	.26
Cylinder, dark	gal.	.18	.19
Extra cold test	gal.	.26	.31
Paraffine, high viscosity	gal.	.294	.30
Paraffine, .903 spec. gr.	gal.	.214	.22
Paraffine, .865 spec. gr.	gal.	.184	.19

Flotation Oils

Pine oil, steam distilled	gal.	.58	—
Pine oil, destructively distilled	gal.	.46	—
Pine-tar oil	gal.	.19	—
Pine-tar oil, double refined	gal.	.27	—
Pine oil, light	gal.	.37	—
Pine oil, heavy	gal.	.26	—
Pine tar, thin	gal.	.18	—
Turpentine, crude	gal.	.38	—
Hardwood oil, f.o.b. Michigan	gal.	.16	—
Cresote, coal tar, neutral	gal.	154	—
Cresote, coal tar, acid	gal.	.214	—
Coal tar, thin	gal.	.11	—

Vegetable and Other Oils

China wood oil	gal.	.12	.124
Cottonseed oil, crude	gal.	.82	.83
Linseed oil, raw	gal.	.92	—
Peanut oil, crude	gal.	.88	.90
Rosin, 2801 b.	bbl.	6.55	—
Rosin oil, first run	gal.	.38	—
Soya bean oil, Manchuria	gal.	.114	.124
Sperm oil, bleached winter, 38 deg.	gal.	1.00	1.02
Turpentine, spirits	gal.	.55	.56

Miscellaneous Materials

Barytes, floated, white	ton	25.00	35.00
Brewast, white, pure	lb.	.45	.50
Carnauba wax, highest grade	lb.	.57	.62
Chalk, light, precipitated, English	lb.	.044	.054
Feldspar	ton	8.00	12.00
Fuller's earth, powdered	100 lb.	.80	1.05
Plaster of Paris	bbl.	1.50	1.70
Red lead, dry, carloads	lb.	—	.094
Sompatone	ton	10.00	12.50
Talc, American, white	ton	10.00	13.00
White lead, dry	lb.	—	.094

Refractories, Etc.

(F.O.B. WORKS)

Chrome brick	net ton	120.00	130.00
Chrome cement, Grecian	net ton	80.00	90.00
Chy brick, 1st quality fireclay	per 1000	40.00	50.00
Maroonite, Grecian, dead burned	net ton	85.00	90.00
Magnesia brick, Grecian, 9x4x2 1/2	net ton	135.00	140.00
Silica brick	per 1000	40.00	45.00

Ferrolloys

Ferro-carbon-titanium, carloads	lb.	.08	.15
Ferromanganese	ton	15	Nominal
Ferromanganese domestic, delivered	ton	4.00	175.00
Ferromolybdenum	ton	100.00	—
Ferrosilicon, 50 p. c., carloads, del. Pittsburgh	ton	100.00	—
Ferrotungsten, 75-85 p. c., f.o.b. Pittsburgh	lb.	2.30	—
Ferrovandium, f.o.b. works	lb.	2.75	3.00

INDUSTRIAL

Financial, Construction and Manufacturers News

Financial

Alaska Hydraulic Mines, Inc. Catipal, \$1,000,000. Incorporated in Delaware to mine gold, silver, copper, lead, zinc, etc., by Norman P. Coffin, Herbert E. Latter and Clement M. Egner, all of Wilmington.

The Alabama Wood Oil Company, Mobile, Ala., has been incorporated with a capital of \$15,000 to manufacture wood, animal and mineral oils. The incorporators are O. E. Childs, Moline, Ill.; J. E. Drysdale, W. W. Bailey, Davenport, Iowa, and the American Wood Oil Co., Wilmington, Del.

Amber Chemical Corporation, New York, has been incorporated with a capital of \$30,000 to manufacture chemicals and drugs. Incorporators are A. Sinclair, 15 Wall Street, New York; A. L. Bykeeper, 1642 Decatur Street, Brooklyn; C. G. Francis, 15 Wall Street, New York.

Anthony-Hammond Chemical Works, Inc., New York, has been incorporated with a capital of \$100,000 to manufacture benzoate, beta naphthol products, etc. The incorporators are E. N. Carey, M. Tischer, H. C. Quinby, 165 Broadway, New York.

The Antimony & Compounds Company of America has been incorporated in New Jersey with \$200,000 capital. The company formerly operated in Belgium. The office of the company will be in the town of Pisataway, Middlesex County, and the incorporators are: Joseph Dhavernas and Eric Goodwin, both of New Brunswick, and Robert Louis Hosnet of New York. Chemicals will be manufactured.

Barnett-Burgess Chemical Company, Hackensack, N. J. Capital, \$100,000. Incorporated to buy, sell, extract and deal in alum, sodium, silicon and metals, by C. O. A. Corth, Hackensack, N. J.; Robert A. Van Voorhies, Jersey City, and Arthur R. Oakley, Pearl River.

Bowditch Dye Works, of Putnam, Conn., incorporated with \$50,000 capital by Detoxer Elliott, George A. Vaughn of Thompson, Benjamin Linesey, Jr., of Waukegan, and Fred Ashton of Putnam.

Bradford Oil & Gas Co., Bradford, Pa., has been incorporated with a capital of \$125,000 to produce, refine and prepare for market petroleum, coal, natural gas, etc. Incorporators: A. S. Williams, F. H. Wright, Bradford, Pa.; A. E. Magee, Dover, Del.

The Bridgeport Iron & Metal Co., Bridgeport, Conn., has been incorporated with a capital of \$10,000. Incorporators are William and Aaron Olderman of Ansonia, and C. Nowits of Bridgeport.

The Brompton Pulp & Paper Company, Ltd., incorporated in Canada with \$9,000,000 capital. Headquarters, Montreal.

The Bryant Paper Company of Kalamazoo, Mich., and the Oxford Paper Company of Rumford Falls, Me., have purchased the Edward Hartington Pulp & Paper Company of St. Johns, N. B., for \$3,000,000. A new company was organized to be known as the Rumford Pulp & Paper Company and will have offices in New York. Improvements on the mill property, costing \$250,000, will be made immediately, insuring a capacity of 100,000 tons daily. The incorporators are P. J. Chisholm, president; L. M. Bickford, vice-president; F. E. Tufts, treasurer; L. H. Drummond, secretary, all of Rumford Falls; P. Milham and W. P. Milham of Kalamazoo are heavy stockholders and directors.

The Rutherford-Judson Corporation has had a remarkable year, as evidenced by a letter issued by Chauncey Brock & Co., New York and Philadelphia, bankers. The company has plants in Newark, Roston and Baltimore, and it is estimated that for the first year in months this year the corporation earned \$3,600,000. September earnings were almost \$550,000 while in October the figures exceeded \$670,000. The ratio of increase has been a full head. The beginning of the construction of new plants begin in the late summer. The letter has the following to say in regard to the Rutherford-Judson products: "This year our corporation is producing large quantities of high-grade acids on war orders. To its ordinary chemical production, including the manufacture of milline acid, it has added muriatic acid, carbonic acid crystals, sulphuric acids and picric acid. The company's output of picric, carbonic, sulphuric, nitric and mixed acids is used mainly in the manufacture of explosives. The demand for the company's output of

acids for explosives has greatly curtailed the time which it has been able to devote to the development and production of dyes. But the company's plants, both its main factories in New Jersey and the new factories which have been constructed in Boston and Baltimore, have been carefully equipped so that on short notice they might be readily converted to the manufacture of dyes, when the abnormal demand for acids stops.

The Central American Oil Co., Dover, Del., capital \$5,000,000, is incorporated to acquire and develop oil lands by Geo. W. Dillman, F. D. Buck and K. E. Longfield, of Wilmington.

Chambers-Haber Chemical Co., Cleveland, Ohio, capital, \$50,000. Incorporators: Charles M. Swingle, Henry W. Haber.

Citizens Oil & Gas Company, Wilmington, Del., capital, \$150,000. Incorporated to manufacture and market crude oil, petroleum, etc., by Herbert E. Latter, Norman P. Coffin and Clement M. Egner.

Colossus Copper Co., Dover, Del., has been incorporated with a capital of \$3,000,000 to mine for gold, silver, lead, zinc, etc. The incorporators are F. R. Hansell, George H. B. Martin, S. C. Seymour, of Philadelphia, Pa.

Colorado Pure Lead Corporation, New York, has been incorporated with a capital of \$115,000 to manufacture drugs, acids, alkalis, esters, extractions, etc. Incorporators are H. Alexander, L. M. Woodworth, J. L. Rawlinson, 40 Wall Street.

Conservation Oil & Gas Co., Parkersburg, W. Va., capital, \$150,000. Incorporated with a capital of \$25,000. Incorporators are C. S. Shepherd, Laura E. Shepherd, Emily D. Bukey, Estelle M. D. O'Blenness.

Coyote Mining Company, Northport, Wash., capital, \$250,000. Incorporators: J. E. Herron, L. W. Cook and George Osterhout.

Cuban Oil & Gas Co., Tulsa, Okla., has been incorporated with a capital of \$25,000. Incorporators are R. M. Kincaid, W. C. Wolfe, R. J. Conaway.

The Cuban Sugar Mill Corporation is being organized in Duluth, Minn., with a capital stock of \$5,100,000.

The Doerr Glass Company, Vineland, N. J., has been incorporated to manufacture and deal in glass. Capital, \$50,000. Incorporators: Herman R. Doerr, Francis Doerr and Albert J. Doerr.

Eklawa Oil & Gas Company, Bristow, Okla., capital, \$100,000. Capital stock, \$50,000. The incorporators are Henry Lowenstein, Conrad F. Ekfelt, St. Louis, Mo., and Sam K. Wasaff, Bristow.

The Elmstrom Leather Company, Boston, Mass., has been incorporated with \$25,000 by Robert Elmstrom, Elmer L. Elmstrom and Hilda E. Johnson.

The Eureka Crucible Flake Graphite Company, Inc., of Saratoga Springs, has been chartered in New York State to carry on a general mining business. Directors: Emmit T. Lee, Frank W. Lee and Will H. Smith.

The Famol Company, Washington, D. C., has been incorporated with a capital of \$35,000 to manufacture chemical preparations of various kinds. The incorporators are W. G. Mertz, F. L. Pickham, F. Vansant, all of Washington.

Feldman-Blair Petroleum Company, Dallas, Texas, has been incorporated to have their name changed to the National Oil & Refining Company.

Fritz Oil & Gas Co., Zanesville, Ohio, is incorporated with a capital of \$20,000. The incorporators are O. Burkhardt, W. L. Swingle, J. L. Swingle, H. E. Baker and Frederick S. Baron.

General Synthetic Co., 234 Lincoln Avenue, Cleveland, Ohio, incorporated with \$100,000 capital to manufacture chemicals.

Globe Refining Company, Houston, Tex., capital \$10,000, is incorporated by R. L. Blaffer, W. S. Parish and S. B. Parish.

Graphite Milling Company, Birmingham, Ala., capital \$100,000, with \$75,000 paid in. Incorporators: Roswell H. Cobb, Ray M. Stearns, and C. D. Brown. The company is understood to have in mind the operation of graphite mills.

Guernsey County Oil Producing Company, Cleveland, Ohio, incorporated with \$100,000 by M. A. Davidson, J. E. Mathews, G. H. Knippenberg, Maurice Masche and H. O. Evans.

The Gunderson Mining Company, with its principal place of business at Deerwood, has been incorporated by C. C. Adams,

president and treasurer, Cuyler Adams and R. M. Adams, secretary, all of Deerwood, D. R. Cotton and A. H. Warren, Jr., vice president, both of St. Paul. The capital stock is \$50,000.

The J. Frank Hays Company, Camden, N. J., has been incorporated with a capital of \$25,000 to manufacture leather. The incorporators are F. R. Hansell, J. A. McPeak, I. C. Clow.

The Hay Creek Oil Company, Santa Anna, Tex., capital \$20,000, is incorporated by Jason Tyson, John Campbell, S. J. Fieralt, and others.

The Holland Furnace Company, Holland, Mich., will increase its capital stock from \$250,000 to \$300,000 to finance a new plant.

Hoyt-Davis Oil Company, Houston, Tex., is incorporated with \$200,000 by G. H. Davis, L. C. Abell, W. W. Parker and J. M. Brown, all of Houston.

The Imperial Chemical Co., Grand Rapids, Mich., has been incorporated with a capital of \$100,000 to manufacture all kinds of spraying material and disinfectants. The incorporators are W. L. Moor, C. R. Slight, J. D. Cass, D. C. Scribner, F. J. Pickett, of Grand Rapids.

Intermediate Chemical Corporation, New York, has been incorporated with a capital of \$1,000. Incorporators are M. Reed, A. C. Burrage, Jr., H. Lawson, 497 Dean Street, Brooklyn.

Lester's Tanning Company, Boston, Mass., is incorporated with a capital of \$300,000, 12,000 shares at \$25 each. The directors are E. C. Fischer, president; Alexander E. Rose, Roxbury, treasurer, and Alfred Karp.

Industrial corporations and domestic railroads have borrowed \$2,073,719,500 since Jan. 1, according to figures compiled by the *Journal of Commerce*.

New corporations to manufacture war material, dyes and chemicals, to produce oil and refined oil products, and to build ships, have a combined capitalization of \$922,435,000.

The Krebs Pigment & Chemical Company, Newport, Del., has increased its capital from \$1,000,000 to \$2,000,000. The Krebs Oil & Gas Co., Tulsa, Okla., has been incorporated with a capital of \$10,000. Incorporators are Dr. J. J. McKanna, Dr. D. W. Conger, W. H. Brown.

The Lackawanna Iron & Steel Company, interests at Lebanon, Pa., in the Cornwall ore mines and also the Freeman interests in the Cornwall Railroad, ore mines and furnaces at Cornwall have been purchased by Charles M. Schwab. This gives Mr. Schwab control of the Cornwall ore mines. He will own outright the American Iron & Steel plants, including the \$2,000,000 steel mill plant and the twin Polebrook furnaces, and will direct, under lease, the Twin Bird Coleman furnaces at Cornwall, Pa., the Cornwall Railroad and the Freeman interests in the Cornwall mines.

Leedsdale Foundry & Manufacturing Company, Wilmington, Del., has been incorporated with a capital of \$30,000 to manufacture iron, steel, etc. The incorporators are H. E. Latter, N. P. Coffin, C. M. Egner.

The Liberal Oil & Gas Company, Dallas, Texas, has been incorporated with a capital of \$125,000. Incorporators are A. M. White, G. W. Sawyer, J. C. Mahoney.

Los Angeles Glass Co., Los Angeles, Cal., Capital \$10,000. Incorporators, John Spring, Kate L. Spring and George W. Averill.

Met-Oh-Lene Co., Inc., New York, has been incorporated with a capital of \$32,500, to manufacture dyes, chemicals, paints, etc. The incorporators are L. Frank Meyer, H. E. Reid, 165 Audubon Ave.

Middle West Fertilizer Co., Springfield, Mo., is incorporated with a capital of \$100,000. The incorporators are J. H. Campbell, Douglas, Augustus H. Dean, Otto A. Koch, C. H. Leach and James B. Yaw.

Mountain Sulphur and Oil Company, Houston, Texas, capital \$100,000, is incorporated by E. A. Cox, D. E. Teague, M. C. Hale.

The oil plant of the National Oil Company, formerly leased to the Shell Oil Company at Rodeo, has been purchased by Frank Milliss for \$50,000.

Nevin Chemical Company, Wilmington, Del., is incorporated with a capital of \$200,000 to manufacture chemicals, drugs, etc. The incorporators are Herbert E. Latter, Norman P. Coffin and Clement M. Egner of Wilmington.

New Healdton Oil Company, Ardmore, Texas, is incorporated with a capital stock of \$150,000. The incorporators are Jake L. Hamon, Chicago, Harold Wallace and J. S. Miller, Ardmore.

Oneta Refining Company, Oneta, Okla., is incorporated with a capital of \$50,000. The incorporators are F. B. Misener, Charles F. Blitt and C. D. Brown.

Optimis Manufacturing Company, Portland, Me., has been organized with \$150,000

capital to manufacture and deal in varnishes, paints, etc., J. Stewart Holliday, Dorchester, Mass., is president. M. A. Reunard, Dorchester, is treasurer.

Oxytherm Chemical Company, San Francisco, Calif., has been incorporated with a capital of \$250,000. Incorporators are H. Carr, John Robert L. McNealey. The company will deal in alkalis and chemicals.

The Pacific Coast Steel Company stock owned by the T. P. Donahue interests, H. Carr, John Robert L. McNealey. The company will deal in alkalis and chemicals.

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The Paragon Refining Company, Toledo, Ohio, has been incorporated with \$750,000 capital stock over the plant and other property of The Paragon Refining Co. of Ironville, Va. The incorporators are J. C. Carr, W. C. Carr and Nathan Fuller. The company will be reorganized. The plant is located on the Maumee River and covers 21 acres. It has a capacity of 45,000 bbls. per month. The plant and additional property are contemplated to bring the capacity up to 60,000 bbls.

Peerless Paint Products, Inc., Bronx, New York, is incorporated with \$40,000 capital to do business in paint, oil and varnish. Incorporators: H. M. Kahn, S. Traub, S. E. Rosenstein, 1221 Brook Ave., Bronx.

Redux Oil and Gas Company, Tulsa, Okla., \$50,000 is incorporated by Thomas D. Lyon, H. P. Rambo, L. G. Livesay, of Tulsa.

Reid Creek Mining Company, Seattle, Wash., capital \$250,000. Incorporators: Otto Leinhecker, Joseph R. Austin, and A. C. Crookall.

Roune County Oil and Gas Company, Charleston, W. Va., has been incorporated with a capital of \$350,000. Incorporators are L. R. Martin, F. J. Holup, L. T. Sanders, E. C. McHugh and R. T. Rosselz. The company will develop oil and gas properties in The Roune County district.

Charles M. Schwab has purchased for the Bethlehem Steel Company, the controlling interest in the Jackson and Reading plants of The American Iron and Steel Manufacturing Co., confirming a report recently circulated that the purchase would be made. The plant is a modern twin bolt and nut plant, car forging, car and railroad materials plant, and a new electrically operated steel mill. The purchase is said to involve \$3,000,000.

Seafmons Oil Co., capital \$1,000,000. Incorporated to buy, sell and deal in oil, gas and minerals, by Herbert E. Litter, Norman P. Coffin, and Clement M. Egner, all of Wilmington, Del.

Sefton Manufacturing Corporation, Milbrook, N. Y., has been incorporated with a capital of \$3,250,000. The manufacture of iron, steel, copper and products. Incorporators are D. Havens, 55 Ilanson Pl., S. C. T. Dodd, 1918 Avenue H, Brooklyn, A. E. Moore, 29 Arden St., New York City.

The A. G. Smith Corporation has secured a New York charter. Capital \$3,500,000. The company will manufacture steel and iron products. Directors are Louis H. Gunther, Samuel B. Howard and Arthur W. Britton.

Springtown Oil and Gas Co., Ft. Worth, Texas, has been incorporated with a capital of \$50,000. Incorporators are Grover Smith, Thomas Pressnal and S. T. Speer.

A group of bankers, headed by Cassatt & Co., and Frazier & Co., of Philadelphia, and White and Merritt, of New York, Lynch & Co., of this city has purchased a large interest in the Superior Steel Company of Carnegie, Pa. A new company will be formed which will have a \$1,500,000 stock. The company manufactures hot and cold rolled strip steel and has a capacity of 115,000 tons per annum.

T-P and C Oil and Gas Company, Oklahoma City, Okla., is incorporated with a capital of \$4,000. The incorporators are M. H. Teller, L. O. Pruiett, and G. E. Chaffee (Oklahoma).

The Tith Oil Company, a New York company is contemplating the purchase of the Constantin Refining Company of West Tulsa at a price said to be \$2,500,000. The Constantin Co. has a 5,000 barrel plant.

The Tomboy Gold and Copper Company has been incorporated in Arizona and will have its office in Chicago. The company is capitalized at \$1,000,000. The incorporators are Pearl Skelton, E. R. Little and J. F. Gerald.

Toromata Zinc Mining Company, Joplin, Mo., Capital \$50,000. Incorporators: W. R. Askwith, Frank L. Cody and W. W. Booth.

Transylvania Tanning Co., Brevard, N. C., has been incorporated with a capital of \$250,000. Incorporators are J. S. Silverstein of Brevard, N. O. Dworetzky, A. M. White of Rochester.

Union Coal Tar Products Corp., Del., has been incorporated with a capital of \$1,000,000 to manufacture chemicals, crude petro-

leum coal and tar products. Incorporators are S. A. Anderson, S. B. Howard, L. H. Gunther all of New York.

The United Steel Company, Canton, Ohio, has decreased its capital from \$150,000 to \$150,000.

The Utah Paraffin Oil & Wax Company has been incorporated in Utah with \$10,000 capital to mine and treat ores and metals, oil shale and its by-products. Whether the company will develop the paraffine oil deposits on the west shore of Great Salt Lake or make lamp black from the crude oil and gas wells in Wyoming is uncertain. Salt Lake business men are interested.

Officers of the company are Lawrence Greene, president; W. R. Wallace, vice president; James Ingbreghsen, secretary; treasurer, M. R. Murphy, S. Murphy, M. A. Kyser and O. W. Ewing, with the officers constitute the board of directors.

The Virginia-Carolina Chemical Company has become one of the stockholders of the American Cyanamid company as the result of the sale to the latter of the phosphate rock mines of the Amalgamated Phosphate Company, Florida, in which Virginia-Carolina Chemical had a large interest.

Weiss Drug Co., Inc., capital \$16,000. Incorporated by S. Strauss, A. Weiss and C. Weiss. To do business in drugs, medicines, paints and chemicals, 546 W. 147th St.

White Star Refining Co., Oklahoma City, Okla., has been incorporated with a capital of \$250,000. Incorporators are M. Campbell, L. Paddock, J. B. Enfield.

The Wisconsin Process Company, Milwaukee, capital \$100,000. Incorporated to manufacture and sell chemicals. Capital, \$10,000. Incorporators, A. A. Stettem, L. E. Fichaux and others.

Construction and Operation

Arizona

PRESCOTT.—Engineers and officers of the Anglo-Saxon Smelting & Refining Company were expected in New York from London, England, on Dec. 25, from where they were to go to Prescott with the intention of erecting a large custom smelter. The company is reported to be prepared to spend \$3,000,000. The party consists of G. G. Lemons, Robert L. Service, secretary of the company; Hugh Rose Croup, president, and two metallurgists.

Arkansas

FORT SMITH.—The Athletic Smelter & Mining Company of Joplin, Mo., is erecting a \$125,000 smelter at South Fort Smith. The Business Men's Club has paid \$4,600 for the trace site and railroad right of way for the company.

California

KENNETT.—The \$400,000 electrolytic zinc plant of the Mammoth Copper Company is nearing completion at Kennett, and is expected to be ready for service early in February. The plant is the most complete of its kind in the world.

LOS ANGELES.—Baker Iron Works plant erecting steel and corrugated iron, 160 x 10 ft. addition, equipped with two 25-ton electrically driven traveling cranes. To be plant on North Broadway and Castelar Street; cost, about \$65,000.

SANTA ROSA.—The North of Bay County Press Association has been considering the erection of a co-operative paper mill. Homer W. Wood of Petaluma is president of the association.

VERNON.—The California Chemical Company has prepared plans for a plant 168 x 153 ft., here.

Colorado

GEORGETOWN.—The Colorado Central Mining Company, Edward S. Wiard, general manager, is in the market for supplies for mine, mill, lumbering, and railroad construction. They are desirous of receiving catalogs from concerns who can furnish these materials.

STERLING.—An organization known as the Highland Promotion Company, made up largely of land holders in the territory east of Sterling, is planning to interview the Great Western Sugar Company of Denver, in regard to the erection of a beet sugar plant at Hill. H. B. Davis is president of the Promotion Company.

Connecticut

BRIDGEPORT.—The American Tite & Strapping Company has plans for the erec-

tion of an additional billet mill and a large rolling mill on its property near here, between Yellow Pond, Stratford and Seaview Avenues. The additions will double the present capacity.

Delaware

WILMINGTON.—The Wilmington Leather Company will erect a six-story factory at Second Street and Greenhill Avenue, to cost about \$60,000.

WILMINGTON.—The Wilmington Steel Company, a branch of the Midvale Steel Company, will build several new furnaces as soon as homes can be furnished for 1500 additional workmen.

District of Columbia

WASHINGTON.—According to the annual report of Secretary of the Navy Daniels, the Government plant at Indian Head is producing powder at the rate of 6,000,000 lb. a year, or double the output of three years ago. The sulphuric and nitric acid plants have been expanded sufficiently to take care of the entire needs of the powder factory, thus effecting a considerable saving in this direction. The cost of the powder has been reduced from \$0 to 34c. per lb.

Illinois

QUINCY.—The Monroe Color & Chemical Company has announced that it will erect a new plant here and will manufacture direct black. The company is an outgrowth of the Monroe Drug Company of Quincy, which manufactures various dyes and pigments. The company has been seriously handicapped by the war. Much of the product of the new plant will be used in the Monroe Drug Company's plant. The factory comprises six buildings and the following intermediates will be made: Benzidine, metaphenylenediamine, aniline and H-acid. The plant is complete in every respect and the product has been carefully worked out. E. N. Monroe is head of both the Monroe Drug Company and the Monroe Color & Chemical Company, and his son, Neal Monroe and Earl Cunnins, have perfected the processes and are in charge of the plant, the latter in the capacity of chief chemist.

Indiana

EVANSVILLE.—The Graham Glass Company has announced that it will erect an addition that will double the capacity of its plant and bring the investment up to \$1,000,000. The company recently became part of the Owens Bottle Machine Company of Toledo, Ohio.

Kansas

KANSAS CITY.—The million-dollar oil refinery and car repair shops to be erected by the Sinclair Oil Corporation will be located in Kansas City, Kan. Work will be rushed on the plant in order to complete it next spring. The pipe line being erected by the company from the Eldorado, Kan., and Cushing, Okla., to Kansas City and Chicago will reach Kansas City by that time.

Kentucky

LOUISVILLE.—The Standard Oil Company of Kentucky will erect a refinery with a capacity of 100,000 bbl. per year on a tract of 336 acres recently acquired.

Louisiana

NEW ORLEANS.—The Freeport Mexican Fuel Oil Corporation plans improvements at the St. Bernard Parish, costing several hundred thousand dollars. W. C. Averill, Jr., is directing the improvements. A new plant will be erected on the Saxonholm property. The company receives its crude oil from Tampico.

Maryland

BALTIMORE.—The Curtis Bay Distilling Company, a subsidiary of the United States Industrial Alcohol Company of New York plans a new plant to handle the by-products from the manufacture of alcohol from molasses. The erection of a mammoth grain elevator at cost \$1,000,000 is also planned, on account of the great increase in ocean freight rates. The present plant of the distillery consists of 12 buildings on a acre of land, directly on the deep-water channel of Curtis Bay. The plant was put in operation last summer. The molasses from which the alcohol is made is brought in tank steamers from Cuba.

LONA CONING.—The Lonaconing Glass Company will rebuild the plant recently destroyed by fire. Citizens subscribed \$23,000 toward the \$100,000 cost of the plant by issuing 6 per cent preferred stock.

Massachusetts

ERVING.—The Erving Paper Mill has recently contracted for the erection of two additions to its plant at Stoneville, near Erving, which will double its capacity. The additions will be completed within one year.

Michigan

DETROIT.—The Pontiac Varnish Company will add two buildings to its plant, thereby doubling its output.

MUSKEGON.—The contract for the erection of the new Brunswick-Balke-Collender Company automobile tire plant, to be constructed within the next sixty days, has been let. The company has already started construction on twenty-four double houses for its workmen.

MUSKEGON.—The Old Montague Iron Works will be rebuilt by a big shipbuilding concern.

Minnesota

ST. PAUL.—Armour & Co. has awarded the contract for driving the piling for foundation of a packing house and subsidiary plants to cost \$50,000.

Missouri

KANSAS CITY.—H. M. Evans and F. H. Thwing have formed a company called the Evans-Thwing Refining Company, with \$1,000,000 capital stock. A site has been purchased in Kansas City for a large refinery, work on which will start at once. This will make the fourth large refinery planned for Kansas City. The Standard Oil Company already has a refinery in operation. The Sinclair Oil Corporation has a refinery at a million dollar plant, and the North American Oil & Refining Company will build a \$250,000 plant.

ST. LOUIS.—The Roxana Petroleum Company will build a 10-in. pipe line from Tulsa, Okla., to St. Louis, and will erect a \$1,000,000 refinery in St. Louis. The Roxana Company is owned by Dutch Shell interests and is a big rival of Standard Oil.

New Jersey

PERTH AMBOY.—A contract has been awarded by the Roessler & Hasslacher Chemical Company for the construction of a \$50,000 building.

WOODBIDGE.—The New Jersey Glue Company will erect an addition to its plant.

New York

ASTORIA, L. I.—The Astoria Light, Heat & Power Company will erect a \$50,000 chemical laboratory at Fifteenth Street and Shore Road.

BROOKLYN.—The National Auline & Chemical Company is building a five-story factory which will cost \$100,000 when finished. The company has a factory on Ross Street and the new plant will be an addition to this, being located along the corner. The structure will be used for essential oils.

NEWBURGH.—The Fabrikoid Works plans the erection of a \$14,000 addition to its plant here.

Ohio

CINCINNATI.—The Charles Boldt Glass Company has let contracts for the construction of a new paper mill and a new factory, each to cost \$250,000. The work will be done by the Ferro Concrete Construction Company.

CLEVELAND.—Reported Carlo-Hydrogen Company, Pittsburgh, will erect factory building and add Hemlock Streets; cost, \$75,000. Tom Knight, 250 The Arcade, is Cleveland agent.

CLEVELAND.—Reported by C. H. Miller, 3317 Broadway Road, will erect foundry 100 x 250 ft.; cost, \$35,000. at State Road and Cleveland Belt Line Railroad.

CLEVELAND.—Reported Riester & Thesmauer, 1512 West Twenty-fifth Street, will erect sheet metal plant; cost, \$300,000. near State Street Road and Cleveland Belt Line Railroad.

MARIETTA.—The Pioneer Window Glass Company, whose plant will be located in Westview, has been incorporated. The officers are Joseph E. Froxy, president; Edward H. Knitzer, secretary, and Leon Laitem, treasurer.

YOUNGSTOWN.—The American Sheet & Pipeplate Company has awarded the contract to the Sharon Clay Products Company for 800,000 bricks to be used in the construction of ten additional hat mills at the Farrell works. The new mills are expected to be completed by next August.

YOUNGSTOWN.—The Republic Iron &

Steel Company plans extensive improvements during the next two or three years, including three additional open-hearth furnaces and an addition to the by-product coke plant.

Oregon

ASTORIA.—The Northern Pacific Brewing plant recently taken by Bruce O. Rowan and J. H. Keating will be remodeled and equipped for condensed milk plant; cost \$100,000.

Pennsylvania

BRISTOL.—Rahn & Haas, of Chicago, will build a chemical plant on the Schaffer farm near Bristol. This will make the second plant for which Bristol has been selected as a location during the last few months. The other is a dye plant to be erected by Daniel Walters.

CARLISLE.—The Mount Holly Paper Mills has been purchased by a Boston concern and will be started up again after being idle for several years. The plant will be enlarged.

JOHNSTOWN.—Directors of the Midvale Steel Company have approved the construction of two blast furnaces at the Cambria Steel Company plant here.

KITTANNING.—The plant of the Kittanning Plate Glass Company, valued at \$1,000,000, has been purchased from the late, by Valentin Neuvert of Kittanning for \$82,000. It is reported that the plant will be renovated and operated to capacity.

PITTSBURGH.—The Western Chemical Company, capitalized at \$25,000, which has been manufacturing dyes in Cleveland for two months will erect a large factory in Pittsburgh. The officers of the company are George H. Fleming, president; J. E. Malone, vice-president, and F. S. Summers, secretary and treasurer. The Cleveland address is 1711 Crawford Road, N. E.

READING.—The Carpenter Steel Works has let the contract for a six-story storage building at 2500th Street.

SCRANTON.—Wilson & Co., meat packers, will erect \$250,000 storage, manufacturing and distributing plant at Millin Avenue and Spruce Street. W. J. Cawley, manager, 7 Dockside Place.

TARENTUM.—The West Penn Steel Company will erect an 80 x 100-ft. addition to its open-hearth department, increasing the capacity of the plant 25 per cent. The company now has four furnaces in operation.

Tennessee

CHATTANOOGA.—The new Chattanooga plant of the Kalkbrenner Corporation is having a new house equipped with Webster Manufacturing Company conveying and elevating machinery.

Texas

HOUSTON.—A company has been formed with headquarters in the Kress Building, Houston, Texas, called the Tidewater Sulphur & Manufacturing Company, to exploit a process for mining sulphur with compressed air. The company owns a tract of 115 acres on Galveston Bay on the Houston Ship Channel, 25 miles from Houston. They claim to have at a depth of 900 ft. a solid bed of sulphur 80 ft. thick. It is proposed to obtain this sulphur by using hot compressed air, under 25 lb. pressure. The compressors are to be run with crude oil, using the exhaust to assist in heating the air, for which purpose the compressed air is passed through heaters utilizing the exhaust gases from the engines and also being equipped with crude oil burners. It is claimed that the air can be heated to 350 deg. Fahr. at a temperature of 100 deg. Fahr. will probably suffice. After leaving the second heater the air passes down into the vein of sulphur through a pipe, inside of which is another pipe. The heated air melts the sulphur and the molten sulphur is drawn up through the inside pipe by a pump and passes into a vat. Work will be commenced on a plant in three or four days. The equipment having already been ordered. It is claimed that the system is cheaper than where steam is used and there is no condensate to bother with. Small plant has been constructed using only 250 ft. of pipe in the air-heating coils and is at present in operation by the Producers Oil Company, of Nabors, La., and is to be used to clean out one of their oil wells. Their former method of cleaning by steam caused a great deal of water to be mixed with the oil. The officers of the company, which is capitalized at \$400,000, are W. R. Britton, president; H. P. Rhodes, vice-president; J. C. Tolman, secretary, and DeWitt C. Dunn, treasurer.

MATAGORDA.—Preparations for the opening of the sulphur field at Big Hill are understood to be nearly completed.

Virginia

PULASKI.—The Pulaski Foundry & Manufacturing Corporation, which recently increased its capital from \$25,000 to \$50,000 will use this capital in enlarging its works.

Washington

LA GRANDE.—The American Nitrogen Products Company, Securities Building, Seattle, has closed a contract with the Tacoma municipal electric system for energy to operate the first unit of its plant, which it is erecting at La Grande, at a cost of about \$300,000. The company filed water rights on the Snake-Salt Lake River, 50 miles north of Everett, several years ago, and intended to build its plant there, but pending the decision of the Seattle municipal lighting department as to the advisability of the site for municipal power purposes, decided not to wait until the city of Seattle had waived its claim to the power site.

TACOMA.—Several million dollars worth of improvements are being completed at the Tacoma plant of the American Smelting & Refining Company. They are now building a new refinery, have just completed a new power house and are now building a new brick house and quarters for the men.

SEATTLE.—The American Nitrogen Products Company, capitalized at \$500,000 is building a small plant for the fixation of nitrogen from the air. The company proposes ultimately to build a large permanent factory on the Sauk-Salt Lake River in Snohomish and Skagit counties. C. Craft of Seattle is president of the company and the directors include: Dr. I. Jansen, Dr. A. O. Lee, and C. Nasten.

PORT ANGELES.—An agreement has been made between Whalen Bros. of Mills Creek, B. C., and E. C. and S. S. Francisco, president of the Puget Sound Mills & Timber Company of Port Angeles, whereby the latter will furnish raw material to operate a paper plant. The first unit to be erected will produce 60 tons daily; the whole plant ultimately costing \$750,000.

West Virginia

FAIRMONT.—West Virginia newspaper publishers have been considering the advisability of establishing a paper mill to supply the newsprint for this state. A meeting was held in Fairmont at which committees were appointed to report at a meeting in Parkersburg in January. J. J. Levine of the Telegram at Clarksburg, presided.

Wisconsin

MANITOWOC.—Plans for erection of a large rolling mill in connection with the plant of the Aluminum Goods Manufacturing Company in this city are under consideration, according to President George Vits.

MENASHA.—The Gilbert Paper Company is erecting a large addition to its mill on the South Bank of the Fox River. It will be used for water supply tanks and filters.

Canada

TRAIL, B. C.—The Consolidated Mining & Smelting Company of Canada will increase the capacity of its copper refinery at Trail to 15 tons per day. The company supplies the own blister copper as well as that from the British Columbia Copper Company's smelter at Greenwood, B. C.

WELLAND, ONT.—Contract awarded by Canadian Steel Foundries, Ltd., Ontario, to Ryan & Co., Ontario, for erecting brick and steel addition to plant; cost \$150,000.

Manufacturers' Notes

GAS SHORTAGE IN OHIO.—Glass plants in Sandusky, Ohio, have established their own gas producing plants and no longer have to depend upon the supply of natural gas. They are now able to operate at all times and have an advantage over other glass manufacturers who are now so much depended upon and where there is a shortage.

BAKELITE COMPANY MOVES.—The new address of the General Bakelite Company is No. 8 Borden Building, New York City. The new location larger and better arranged offices materially assist in handling the increasing business.

CHEMICAL PLANTS MUST GET PERMITS.—Chemical plants in the Belleville district along the Passaic River were required to obtain permits from the Board of Health to operate owing to the discovery of a section in the sanitary code by the health officers. The Belleville Metal & Chemical Co., The Edison plant at Silver

Lake and Eastwood Chemical Company and several other concerns are affected.

SUBSTITUTE FOR AMYL ACETATE.—A substitute for Amyl Acetate in the manufacture of aerolite products has been brought out recently by Albert L. Kraus of the Kraus-Millett Co., of Portsmouth, N. H. The new solvent it is claimed fulfills every necessary requirement of the more expensive amyl.

AMERICAN COMPANIES IN CANADA.—Since the outbreak of the European war about fifty American companies have established branch plants in Canada, the cost of which is estimated at \$15,000,000. Prior to the war there were 450 American companies with branch plants in Canada, and the present plant investment represents \$15,000,000. Some of the articles manufactured in Canada by American companies recently located there are as follows:

Railway accessories, overalls, chemicals, silverware and flatware, automobiles, horse-shoes, steel goods, patent medicines, spices, fragrances, perfume, glue, beet sugar, blue-greenhouses, railway signals, fuses, boxes, spreaders, silk gloves, stockings, tires, steel and pulp products, canned goods, automobile varnishes, beet sugar, blue-greenhouses, pulp and paper, sewing machines, aloxite and other abrasives and electric furnace products, grain and elevator machinery, silk and chamois, rubber goods, refined nickel, and cottonseed oil products.

GOVERNMENT NITRATE PLANT.—Congressman Longworth of Cincinnati has introduced a bill repealing the act which authorized the erection of a \$20,000,000 government nitrate plant.

WATKINS WEBSTER SELLS AIR CONDITIONING SYSTEMS.—The Warren Webster & Company of Camden, New Jersey, announces that they have disposed of the business of their air conditioning department, and on and after January 1, 1917, the Webster air conditioning apparatus will be manufactured and exploited by the Braemar Air Conditioning Corporation, Lafayette Building, Philadelphia, Pa.

EAST SHORE AREA AFFECTING PENNSYLVANIA MILLS.—The mills in the Monongahela Valley have been hindered by a shortage in gas and several had to shut down for a time during the first of December, including The Macbeth-Evans Glass Co., The Donora Mills, The United Glass Works and The Pittsburgh Steel Foundry. Officials of gas companies explained that the domestic demand was so great that it was necessary to reduce the supply to mills. The large mills are hurrying work on new fuel systems.

FILTER PRESSES.—The Newport Chemical Works, Inc. of Milwaukee, have placed an order with D. R. Sperry & Co., Batavia, Ill., for presses for filtering wood and iron construction, for their new Carrollville, Wis., plant. These presses will be in the manufacture of dyes.

ELEVATING AND CONVEYING SYSTEMS.—The Webster Manufacturing Company of Tiffin, Ohio, are installing a complete elevating and conveying system in the new extension of the Portland Cement Company, Ironton, Ohio, and a conveying and transmission system at the National Phosphate Fertilizer Company, at Centerville, Tenn., for handling the phosphates.

AUSTRALIAN MARKET FOR CHEMICALS.—Advices have been received from Richmond, Australia that there is a market for calcium, magnesium sulphur and zinc chloride, compressed chlorine and antimony sulphide in Australia.

DISC CRUSHERS.—Chalmers & Williams, Chicago, Ill., Highland, Ill., has recently installed four Symons 48 in. vertical disc crushers. At the Federal Lead Co., Flat River, Mo., two at the Burro Mountain Copper Co., Chiquita, Ariz., six at the Chib. Exploration Co., Chiquita, Ariz., and two at the Calumet & Arizona Mining Co.

DIE-CASTING COMPANY ADOPTS PROFIT SHARING.—A complimentary dinner Dec. 15, tendered to the Doehler Executive Club, which is composed of all the executive heads of the Doehler Die-Casting Co., with factories at Highland, N. Y., Newark, N. J., and Toledo, Ohio, the following announcement was made by Mr. H. H. Doehler, its President and General Manager:

To the employees of the Doehler Die-Casting Co. of Brooklyn, Toledo and Newark.

The Doehler Die-Casting Co. realizes the increasing cost of living. To assist our workers to meet these new conditions and at the same time to reward our loyal workers, we offer to all our employees the following inducements in the form of an extra participating dividend on their wages.

Beginning January 1, 1917, whenever this company declares the regular dividend on their stock it will also declare a wage dividend amounting to 10 per cent per annum to all employees based on all wages actually received including piece work and

overtime. This wage dividend is subject to the following conditions.

1. An employee must be in our employ before interruption for a full year before he can participate in the wage dividend. Upon completion of a full year's employment he automatically becomes a candidate for this wage-dividend. His wage-dividend will be calculated from the date of completing the first year's employment to the date of declaration of dividend.

2. This wage dividend when declared will be apportioned in the following manner:

First—Will be paid in full to all employees who have been in our employ for a full period of three years or more.

Second—Will be paid in full to all employees who have been in our employ for a full period of two years and less than three years.

Third—One-third will be paid to all employees who have been in our employ for a full period of one year and less than two. This wage-dividend will be declared quarterly the same as our stock dividend.

It was further announced that beginning Jan. 1, 1917, all employees who have been working on the basis of 50 hours per week will be put on a basis of 48 hours per week at the same pay, believing as Mr. Doehler said, that 8 hours per day was sufficient for all men who work. This company employs 1,200 men, and has a weekly payroll of approximately \$25,000.

New Manufacturers' Publications

"Arc Welding." A booklet prepared by the Arc Welding Machine Co., Inc., 220 West Forty-second St., New York. Describes the company's new Electrodeless Arc Welding and gives general theory of arc welding.

The Prest-O-Lite Co., Inc., Indianapolis, Ind., has issued an instruction book for lead burning with oxy-acetylene. In the introduction it is stated that the term "lead burning" is somewhat misleading, as the work performed by this process should more properly be termed oxy-acetylene welding. The process has however come into common use. The process is not confined to work in lead but can also be used on tin and other low melting point metals or alloys. The book gives a description of the Prest-O-Lite Outfit and directions for burning sheet lead, storage battery work, joining lead and other pipe, making tees, etc.

Chicago Pneumatic Tool Company, Chicago, Ill., Bulletin E-15, superseding E-40 and describing Duntley portable electric hoists.

Chicago Pneumatic Tool Company, Chicago, Ill., Bulletin 129 describing hose, hose couplings and hose clamps.

Schweitzer & Conrad, Inc., Bulletin 1A, describing S & C extra-high-potential fuses.

Aero-Engine Co., Inc., Bulletin 2, describing pulverizing fuel. Bulletin 25, discussing the advisability of pre-drying coal before burning.

Armstrong Cork Company, Pittsburgh, Pa., "Nonpareil Corkboard Insulation for Cold Storage Rooms" and "Fifteen Years on Brine Lines," the latter describing a service test.

The Mine and Smelter Supply Company, Denver, Colo., Bulletin 34, describing the Lindsay oil burning assay furnaces and oil burners for schools and college agents.

The furnaces and burners are manufactured by The Colorado Crucible and Clay Company.

The Mine & Smelter Supply Company, Denver, Colo., Bulletin describing the Tresser analytical and assay balances with multiple weight attachments, and various accessories.

American Blower Company, Detroit, Mich., Bulletin 13, Series 9, superseding No. 345, and describing Type D and Cyclone Dust Ventilating Fans.

Galvanometer Fans.—Pyroelectric Instrument Company, Trenton, N. J., Circular No. 2, describing galvanometers Ayton shunts, Pyrocommutator and dial resistance dea boxes.

Janney, Steinmetz & Co., Phila., Pa., has issued a bulletin describing "Jasco" seamless heavy retort ware, pots, pans, ink buckets, tanks, etc.

Golden-Anderson Valve Specialty Company, Fulton Bldg., Pittsburgh, Bulletin describing Golden-Anderson automatic valves for protecting steam and water lines.

The Brown Holsting Machinery Company, Cleveland, Ohio, has just put out an attractive catalog of 1917, showing some interesting photographs of underground operations with Brown apparatus at various ore and coal docks, and loading operations on railroad cars.

Chicago Pneumatic Tool Company, Chicago, Ill., has issued Bulletin 34-W, describing "Grant" fuel oil engines.

The Motor Equipment Company of Minneapolis, Minn., has issued a pamphlet describing its vertical alternator for use in small and medium sized hydro-electric plants. The generator is direct connected to a vertical waterwheel shaft, eliminating all grass, belt, rope drives, etc. The weight of the waterwheel and the downward thrust, as well as the revolving parts of the generator, are carried on a roller thrust bearing submerged in oil. It is claimed that these alternators are much more efficient than a gear or belt driven machine.

Handbook of Westinghouse Watt-hour Meters, issued by Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. Gives the early development of watt hour meters, details of Westinghouse meters, constants and test formulas, use of standards and other important details.

Other New Publications

"Facts About Water Power," Prepared by the executive committee of the Water Power Development Association, Munsey Bldg., Washington, D. C. Gives the available water powers, development and development, and shows the demand for further development under adequate laws.

"Production of Iron and Steel in Canada in 1915," by John A. McLean, of the Division of Mineral Resources and Statistics. Published by the Department of Mines of Canada, Ottawa.

Gold, Silver, Copper, Lead and Zinc in Mexico and Texas in 1915," By Charles W. Henderson. Geological Survey Report, Washington, D. C.

"Freezing Point of Mercury," By R. M. Wilhelm. Bulletin, Paper No. 24, of Bureau of Standards. The paper gives results of a determination of the freezing point of mercury using platinum resistance thermometers, and shows the temperature.

Failure of Brass 2.—Effect of Corrosion on the Ductility and Strength of Brass. By Paul D. Merica. Technologic Paper No. 83 of Bureau of Standards.

Failure of Brass 3.—Initial Stress Produced by the Burning In of Manganese Bronze. By Paul D. Merica and C. P. Karr. Technologic Paper No. 84 of Bureau of Standards.

Gold, Silver, Copper, Lead and Zinc in Utah in 1915. By V. C. Heikes. Geological Survey Report.

Government Ownership and Regulation.—Bulletin of Merchants Association of New York, opposing government ownership and operation of public utilities and advocating exclusive regulation of all railroads by the Federal government.

Gold, Silver, Copper, Lead and Zinc in Montana in 1915. By C. V. Heikes, U. S. Geological Survey Report. Mineral Resources of the U. S.

Gold, Silver, Copper, Lead and Zinc in Arizona in 1915. By C. V. Heikes, U. S. Geological Survey Report. Mineral Resources of the U. S.

Annual Report of The Federal Trade Commission. For the year ending June 30, 1916. Government Printing Office, Washington, D. C.

"Practical Handling of Iowa Clays." By Homer F. Staley and Milton F. Beecher. Bulletin 43 of the Engineering Experiment Station at Iowa State College of Agriculture and Mechanic Arts.

Oil Shale in Northwestern Colorado and Adjacent Areas. By Dean E. Winchester. Geological Survey Bulletin 647. Contains information showing that when certain conditions justify it, these Colorado shales can be distilled yielding large quantities of oil and gas, and furnishing nitrogenous by-products for fertilizer.

National Tank & Pipe Co., Portland, Oregon, has issued catalog 14, describing with illustrations and technical details tanks, crossarm silos and steam pipe fittings, and other specialties and giving new tables and information on pipe not heretofore published.

The Federal Trade Commission has issued in two volumes a report on co-operation in American Export Trade being the results of investigations made by the Federal Trade Commission.

Vapor Pressure Measurements.—"Vapor Pressures of Various Compounds at Low Temperatures" is the title of Bureau of Mines Technical Paper No. 42. By G. A. Burrell and I. W. Robertson. The paper gives the results of measurements on ethane, ethane, propane, propylene, butane, acetylene, ammonia, sulphur dioxide and nitrous oxide.

A Study of Oil Engines in Iowa Power Plants. By H. W. Wagner. Bulletin 42 of Engineering Experiment Station at Iowa State College of Agriculture and Mechanic Arts.

Gold, Silver, Copper, Lead and Zinc in Colorado in 1915. By Charles W. Henderson. Geological Survey Report. Part of Mineral Resources of U. S.

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Contents for January 15, 1917

EDITORIAL:

A Riot of Organization.....	67
Economies in Steel Manufacture.....	68
By-Product Coke.....	68
Laziness, Efficiency and the Efficient Laziness.....	69

READERS' VIEWS AND COMMENTS:

A Personal Note. By Joseph W. Richards.....	70
Our Wasting Water Powers. By L. B.....	70
The Recovery of Chinchonine from Any Solutions in Which It is Used to Remove the Last Traces of Tung- sten. By E. W. Hagmaier.....	70
Coming Meetings and Events.....	71
Western Metallurgical Field.....	71
Chemistry at Convention of American Association for the Advancement of Science.....	72
The Niagara Power Situation.....	77
The Tariff and the Business Commissions.....	78
Some Production Statistics for 1916.....	78
The Chemical Industry of Switzerland.....	78
The Human Side of the Development of the Chemical Indus- tries. By G. W. Thompson.....	79
The New York Meeting of the American Institute of Chemical Engineers.....	81
An Investigation of the Brittleness Produced in Steel Springs by Electroplating. By M. DeKay Thompson and C. N. Richardson.....	83
Analysis of Babbitt Metal Alloys of Tin, Antimony, Lead and Copper. By E. W. Hagmaier.....	84
Vaporization of Metallic Copper in Wirebar Furnaces. By Allison Butts.....	85
The Calculation of Lead Blast Furnace Charges for Students of Metallurgy. Part 1. By Boyd Dudley.....	87
Counter-current Decantation. By Luther B. Eames.....	94
The Rubber Situation. By Andrew H. King.....	99
Training the Works Chemist. By Frank E. Lathe.....	103
Synopsis of Recent Metallurgical and Chemical Literature.....	106
Recent Metallurgical and Chemical Patents.....	107
Constant-Current Closed-Circuit Arc Welding System.....	108
A New Non-Corrosive Insulating Compound.....	109
Commercial and Industrial Preparedness in Foreign Countries	110
An Improved Automatic Liquid Weighing Scale.....	110
Work of Bureau of Mines.....	111
PERSONAL.....	113
Current Market Reports—Iron and Steel, Non-Ferrous and Chemical Markets.....	113
Industrial—Financial, Construction and Manufacturers' News	117

A Riot of Organization

"Organization," says H. G. Wells in an essay lately published, "is the life of material and the death of mental and spiritual processes." That is one of those observations that holds true from one angle of vision and is clearly false from another. If we were to say that organization as an end, rather than as a means to an end, kills mental and spiritual processes, there would be few to contradict it. And despite the chaotic state of chemical industry in this country to-day, and the need of organization right and left, it is worth while to remember that over-organization is as bad as disorder.

Nearly every one of us has some little trick that he can perform better than he can do other things, and there is good advice from all grades of intelligence, from genius to orthodoxy, to the effect that we should conserve our talents. But if we were so organized that each of us were under compulsion to repeat his one little trick, over and over again, the livelong day, we should lose in imagination what we should gain in efficiency.

Francis Hackett, whose wit is sharper than everybody can see, lately proposed that eugenics be employed to breed a race of efficient industrial workers who shall be strong, healthy, good-natured and exceedingly dull. In short, he proposes (in satire) a race of morons, of feeble-minded but strong-bodied workers, for efficiency. But the fact is, there are in process of breeding feeble-minded in vast number, and the great task is, as we have said before, to find employment for them. Since manufacturers will not have them if they can help it, the labor unions have had to take them on and slow down their gait to meet the limitations of their dull and incompetent members. The organization of the feeble-minded along with whole men, lest the weak ones starve, is one of the leading reasons why collective bargaining with labor unions is so difficult.

We have in mind a great works the pot-bellied authorities of which point with pride to the speed with which their hands are able to do the same task over and over again throughout the long days and weeks and months and years. The error lies in the belief that the monotony of speed at one task will be profitable throughout the years. They are putting whole men at work designed for the feeble of wit, and just as depreciated currency returns to its source, so the mentally helpless will drift to the jobs designed for them. And good men will degenerate or go away.

Now as many useful ideas emanate from the shop as from the drafting room, and if the men in the shop work as machines rather than as men, or with

their minds asleep, the output may not go down, but somebody else will soon come along with something better.

We can organize the life out of factory practice, and thus cause a waste of men and of ideas on the one hand that is more dangerous than the waste of material and time that comes from the lack of organization.

Economies in Steel Manufacture

The steel industry has always been crying for more capital. When the Payne-Aldrich tariff was under advisement a number of steel manufacturers went down to Washington and asserted that the only way to make money in the steel industry was by selling out. The statement was calculated as a rejoinder to Mr. Carnegie's testimony to the effect that the steel industry did not need protection. Mr. Carnegie was rich—but he had sold out! There was a large element of truth in the statement, however. One could make money in the steel business, perhaps, but he could not take it out; he could not "cash in." There was always the necessity of spending the earnings.

For the first time in the history of the American steel trade there are earnings so large that there is no occasion to spend the major portion of them in plant extensions, in order that each one may keep pace with his neighbor and nobody fall behind. It is impossible, indeed, to spend the major part of the money because there are not enough workmen and makers of supplies, equipment, etc., willing to accept the money. There is a large works extension program being carried out, but it is not absorbing the profits nearly as fast as they are being made. All the improvements made in this expansive movement, which began about the middle of 1915, and all still to be made, would only total in the neighborhood, probably, of \$300,000,000 to \$400,000,000, or perhaps a trifle less than the surplus earnings to date, beyond all charges and the ordinary dividend requirements. There are still large earnings in prospect.

The new construction program, however, is regarded in the trade as very nearly a finality as regards increase in tonnage output. Further improvements that may be made will be in the direction of introducing still greater economies in manufacture, partly by way of saving money on the cost sheet and partly by way of making new products, carrying the steel to a greater degree of finish, and making by-products, of which there may be many apart from the well recognized by-product of the retort coke oven.

As to these refinements the steel industry is in no hurry. Most of them cannot well be undertaken when works are being driven to produce the last ton of steel possible, or when labor and supplies are scarce. The time will come for them in due course.

Of the refinements that are to be considered the further reduction in labor must stand prominent, from both the social and the economic viewpoint. The 12-hour day really has no friends, those who are its sponsors merely considering it a necessity in the circumstances. The iron and steel industry's labor has been

supplied largely by immigration. During the two fiscal years before the war the increase in population of the United States, due to excess of arrivals over departures, averaged 50,000 a month. Since the war started the increase has been light and what may be called a deficiency, having regard to the previous rate, has accumulated to the extent of more than 1,000,000. After the war there will hardly be much of an influx of able-bodied men such as could be recruited into the industry. With a lessened supply of labor in proportion to the industry's growth and with a tendency to shorten the hours of labor the unskilled labor must be displaced more and more by machinery, and the industry will not find itself, as it occasionally has in the past, with neither the money to pay the men nor the money to buy the machinery with which to replace them.

By-Product Coke

A function, if not a use, has been found for the beehive coke oven, to take the peak off the load. According to the estimate just made by the Geological Survey coke production in 1916 was about 19,200,000 net tons by the by-product process and 35,100,000 tons by the beehive oven, making a total of 54,300,000 tons. Although the increase in by-product coke from 1915 to 1916 was 36 per cent, the increase in the proportion of by-product to total coke was only from 34 to 35 per cent. The production of beehive coke had "come back" under stress of demand so that the year's tonnage was substantially equal to the record tonnage, made in 1907, when it constituted 86 per cent of the total output. In the intermediate years the tonnage was much less.

The demand for coke, inasmuch as 80 per cent of the total output, on an average, is used in the manufacture of pig iron, fluctuates widely. By reason of the large investment involved in by-product ovens it is desirable that they should operate with a fair degree of continuity, and it will be convenient to have the beehive ovens to fall back upon at times, to eke out when there is an extraordinary demand.

By-product coking practice, in the latest developments, has been kinder to the beehive coking coal fields than was expected. The wind has been tempered to the shorn lamb. In recent years there has been a trend toward larger proportions of the coals hitherto used in beehive practice than had been anticipated, and thus the beehive operations can continue, by shipping their coal to by-product ovens, and in times of stress increasing their coal output and coking the excess in their old beehive ovens.

The number of by-product ovens completed at the beginning of this year has not yet been reported, but the number on January 1, 1916, was recently reported at 6268, and the number since completed, or now under construction, will bring the total to about 9000 retorts. The actual statistics of production do not reflect the outputs claimed possible with ovens as now built, but the newer ovens will doubtless do better. Giving the retort the benefit of the doubt, and assuming that only those completed by the beginning of a year contributed

to the year's output, the average output per retort has been, according to the Geological Survey's reports: 1912, 2400 tons; 1913, 2440 tons; 1914, 2130 tons; 1915, 2430 tons; 1916, 3050 tons. Most of these years were years of substantially full operation.

In the circumstances it seems perfectly safe to predict that the ovens now built and those being built will have a capacity of fully 30,000,000 net tons of coke per annum. When the blast furnaces now being built are completed the total pig iron capacity will be close to 45,000,000 tons a year, requiring in the neighborhood, according to the experience of 1915, about 50,000,000 tons of coke a year. Thus there is still much room for growth in the by-product coke industry.

Laziness, Efficiency and the Efficient Laziness

In Mark Twain's classic we find that the youthful hero "Tom Sawyer" had on a Saturday the hard job of whitewashing a fence thirty yards long and nine feet high. His thoughts wandered to the swimming hole. He was feeling just so "plum lazy" that he did not like the appalling task. So he thought, as the real prototype of the modern efficiency that he would use his head rather than his hands, and accordingly placed his job before his friends in the pleasing light of that of a noble craftsman. We all know the sequel: He got his pals to pay for the privilege of doing his work for him and he arrived at "the efficient laziness."

Now, laziness with us has an unpleasant connotation suggestive of the "bum," and usually means the disinclination to do honest work of any kind. But it can carry the further meaning of the disinclination to do any unnecessary work and of the desire to get machinery to perform the work and not waste energy. We believe that from the all-pervasive human tendency to do no work, or at least a minimum of work, perforce is born the inventive instinct, and in this secondary meaning of laziness there is a lesson. From the lazy notion that the unloading of dirt from a cart was hard work came the dump-cart. The disinclination to delve, developed the plough. A tread-mill is a poor prime-mover—hard, laborious effort of man or beast produces only a few foot-pounds per minute. But Watts made the stored-up sunlight of ages produce the equivalent of many men and horses. Doubtless, the steady grind of the tread-mill is good to an extent for both man and beast, but it is not elevating to them, either in a spiritual or in a physical sense. And the intelligent way was for man to develop some other prime-mover. The waterwheel turning round absorbs the potential energy of stored water. The old "overshot" wheel spilled and splashed round water, but was very inefficient. It made a fine show and was "beautiful," but it was not useful. A modern large turbine discharges its water in a slow and lazy stream into the tailrace and is efficient. The lazy man "cuts off" his steam and allows it to expand as happens in a Corliss engine.

Noise and splash are signs of activity, but not of intelligent activity. They show wasted effort. In all human endeavor, there is the attempt to perform the minimum effort and to produce the maximum result.

This is not exactly what we usually call laziness, but it surely is closely allied to laziness in its general meaning and it is "the efficient laziness." A lazy man is naturally graceful. He is so "darned lazy" that he will make no unnecessary motion and moves with languid ease and grace. He is not over-anxious or too eager. He does not slop over or waste his energy for he prizes energy so highly that he uses every bit of it. Impelled by the thought that he must live, he develops his intelligence and moves along the line of least resistance. To get out of doing hard work, he will devise and use levers, cams, electromagnets, relays, belts, clutches and gears. All these are born of the innate desire of man to escape effort, and out of this situation intelligence arises to give birth to expedients and other means to escape drudgery.

Just as the most beautiful flower, the rose, grows out of animal corruption, so does intelligence grow out of laziness.

Now, of course, there must be energy of some kind as the impelling force and without energy nothing can proceed, for the rationale of energy lies in its utilization. The command of nature is that energy must not be wasted by man. The prizefighter who spars with rigid muscles is quickly worsted by his antagonist who moves relaxed except at intervals of intense effort. The long-distance runner goes on his pace with a graceful lope if he is to be the winner. Whereas his competitor runner who bounces up on the muscle of his calves soon exhausts himself and an excess of uncontrolled energy is the cause of that great American malady, "nervousness." No lazy man fidgets.

Indeed, an intelligent and efficient laziness is the greatest of America's needs. "Pep," "punch" and "kick" are fine national assets, but to be using them continually soon dulls their edge and wastes them. Observe if you will the wild animals who have no consciousness to arouse them to pernicious activity. When they lie down, they are relaxed. When they move slow they move with a lazy motion. There is no living creature more efficiently lazy than the lion. When he moves fast he moves with no lost motion, and with a magnificent spring. He is the great unconscious engineer.

Engineering and invention proceed from laziness. Is there anything more conducive of laziness than the "slide rule?" So, then, while laziness, like manure, is not always pleasant and should be put under the ground out of sight, a clear understanding of the proper use of this supposedly smelly and not always agreeable human quality will help the chemist and engineer, but not if carried to the point of self-deceit. For laziness if unintelligent brings forth self-deceit. This, however, is not "the efficient laziness."

The efficient lazy man is the apogee of the sine-curve of intelligence. When he toils, he spins.

The stock proverb on this subject we know was "Go to the ant, thou sluggard, consider her ways and be wise." Should it not be, "Go to the sluggard, thou ant, consider her ways and be efficiently lazy." "Be sure when you nip the aphid-worm that you use only three nips, instead of the five that you have been using."

Readers' Views and Comments

A Personal Note

To the Editor of Metallurgical & Chemical Engineering

SIR:—With your permission, the undersigned would like to make public the fact that the "J. W. Richards" endorsing circulars recently issued exploiting Mr. Sydney J. Jennings for president of the American Institute of Mining Engineers, is Mr. John W. Richards of Denver, and not Dr. Joseph W. Richards, vice-president of the Institute and chairman of its Iron and Steel Committee.

JOSEPH W. RICHARDS.

Lehigh University.

Our Wasting Water Powers

To the Editor of Metallurgical & Chemical Engineering

SIR:—Your journal is right in drawing again and again attention to the enormous importance of the water-power problem at Niagara and elsewhere at the present time.

Through a long course of legislative fatuousness our country has lost millions of dollars in wasted power, and stands to lose many millions more unless the present situation is remedied. The fundamental economic principle about hydraulic power is that every cubic foot of water that plunges downward unutilized is a sheer waste of inherent national wealth. If you do not dig up your coal or cut down your wood its fuel value remains, while in the case of unused water powers the water of the present runs to absolute waste. All the value which it represents is as completely lost as if it were T N T exploded at the front with the amiable intent of blowing a few fellow mortals off the earth.

When a country is only partly settled and manufacture is a casual rather than a vital industry the neglect of hydraulic privileges represents less immediate and serious loss, but as the nation's industrial resources are more and more thoroughly developed and particularly as electrochemical processes have come to take a greater and greater part in the economic result, neglected powers are more than regrettable, they are disastrous. Electrochemical works require plentiful and cheap power such as can be obtained only by the utilization on a big scale of the big streams, even navigable streams, as well as others in the public domain. And how great a part electrochemical processes play in manufacture apparently only remotely related to them your journal is continually pointing out.

The fullest possible power supply obtained within the shortest possible time is the fundamental requirement for that complete organization of American industry which is necessary to the prosperity of the nation now, and will be even more vital within the next few years. It is up to Congress to show some signs of patriotism and human intelligence instead of playing politics and talking buncombe in the effort to disconcert an alleged water power trust that does not exist. It is not remarkable that far-sighted folk should be interested in the development of water powers, and the movement toward this end is as spontaneous as hunting after any other article of well-known and established value.

Those who oppose hydraulic development fall into three categories: First, come the narrow-minded souls who shudder with fear lest somebody else make a dollar by judicious investment; second, that amiable group

of socialistic proclivities, who want the Government to screw enough out of each projected enterprise to wreck it as a business proposition; and third, come the long-haired and mild-eyed sentimentalists who whine about dangers to the beauties of Niagara—for the last half century a dismal congeries of cheap hotels, boarding houses, bawling cabbies and open-mouthed bridal couples. The sentimental value of a great cataract is is not unworthy of consideration, but this particular one had lost all esthetic importance before the first power plant burrowed its tail-race through the cliffs.

The thing of vital importance to the country at the present time is that all the sources of hydraulic power which are economically available should be brought quickly into use so as to give modern industry a fair chance. The water which is not used to-day is lost capital. We need water power legislation which shall give encouragement toward the immediate development of every horsepower worth the while, with provision to protect the government in its ownership if you like, by regulation of prices and by limitation of charter rights, but constructive instead of destructive as at present.

It must be remembered that the most promising of such enterprises are big ones not to be carried out by a small investment and in a single season. They require large amounts of capital which can be had cheaply if reasonable security for its investment can be granted. Time, too, is required so that if two or three years from now there is to be cheap power for the multifarious uses men find for it, a beginning must be made at once.

Public service enterprises such as these do not resent reasonable supervision. They have on the contrary learned to expect it, but they cannot exist in the face of uncertainty with respect to reasonable profits and tolerable continuity of business. The tendency of legislation seems to be to cultivate uncertainty and to leave the would-be investor quite in the dark as to whether his property will be his own a few years from now or will have been in some way benevolently assimilated by the powers that be.

The important thing for far-sighted legislators to realize now is that the thing at stake has to do with the conditions of permanent prosperity as respects many of the country's big industries. It is a question of substituting frugality for waste, of building up instead of tearing down, of looking to the benefits of the future instead of whining over the peccadillos of the past.

L. B.
Boston, Mass.

The Recovery of Chinchonine from Any Solutions in Which It Is Used to Remove the Last Traces of Tungsten

To the Editor of Metallurgical & Chemical Engineering

SIR:—Owing to the great advance in price and the difficulty encountered trying to procure chinchonine for the determination of tungsten, the writer has been using the following method to recover this reagent from filtrates in which it has been used.

Place the waste filtrates which contain the chinchonine into a suitable container until 5 or 10 gal. have accumulated. To this solution add slowly and with constant stirring a strong solution of commercial caustic soda until the solution is just slightly acid. When this

point is reached add an emulsion of zinc oxide until all the iron, etc., is precipitated. If when this point is reached the precipitate seems too thick so that no clear solution shows at the top, then add several liters of tap water and allow the precipitate to settle.

When the precipitate has entirely settled, decant off the clear solution. To this clear solution add ammonium hydroxide, having enough in excess to redissolve any zinc which might precipitate. The amount of ammonium hydroxide needed here will depend on the amount of zinc oxide needed to precipitate the iron, etc. If the solution was brought close enough to the neutral with caustic then the amount of zinc oxide will be smaller and it will not require such a large excess of ammonium hydroxide. Of course, if some zinc is precipitated with the cinchonine at this point it will not matter so much as it will be removed later during the process of purification. The only thing that the zinc does here is to retard filtration of the cinchonine.

When the ammoniacal solution is obtained it will also contain a grayish white precipitate of the impure cinchonine. Filter off this precipitate, using a Buchner funnel and suction. Wash the precipitate several times with hot water, suck dry and then dissolve the precipitate from the filter with hot (1-1) hydrochloric acid, washing the filter several times. This acid will dissolve the precipitate from the paper. To this solution add some tartaric acid and again make ammoniacal, a white precipitate of cinchonine should be obtained. This precipitate is filtered off and thoroughly washed with hot water, dried at 105 deg. C., and bottled for use in making cinchonine solutions.

The precipitate of iron from which the clear solution was decanted in the first place is stirred up and tap water added and the precipitate again allowed to settle and this clear solution again drawn off and the cinchonine recovered from this as explained. By making several decantations of this kind it has been able to recover at least 90 per cent of the cinchonine.

The filtrate from the purification of the first precipitate of the cinchonine is saved and used to precipitate the cinchonine from the second decantation from the iron precipitate. In this way a saving on the amount of ammonium hydroxide needed can be made.

Buffalo, N. Y.

E. W. HAGMAIER.

Coming Meetings and Events

Society of Chemical Industry, New York Section, Perkin Medal Award, New York, Jan. 19, 1917.

Joint meeting, New York Sections, American Electrochemical Society and American Institute of Mining Engineers. Machinery Club, New York, Jan. 26, 1917.

Joint meeting of New York Section of American Electrochemical Society, American Chemical Society and Society of Chemical Industry, Rumford Hall, Chemists' Club, New York, Feb. 9, 1917.

American Institute of Mining Engineers, annual meeting, New York, Feb. 19-22, 1917.

Meeting of New York Sections of American Electrochemical Society and American Institute of Mining Engineers

A joint meeting will be held on Friday evening, Jan. 26, by the New York Sections of the American Electrochemical Society and the American Institute of Mining Engineers. The topic of the evening will be "The Electrical Precipitation of Smoke and Dust." It will be a dinner meeting (charge \$1.75, including drinks), and will be held at the Machinery Club, 50 Church Street, at 6.30 p. m. Messrs. Linn Bradley, W. W. Strong and A. F. Johnson will speak.

Western Metallurgical and Chemical Field

Gasoline from Oil Shales

A great deal of interest has of late been shown in various parts of the world in connection with the extraction of gasoline from shales rich in hydrocarbons. It is not impossible that in future, due to the advancing cost of gasoline from petroleum, means may be sought from which this much demanded product can be produced independent of the oil syndicate.

For three years the U. S. Geological Survey has investigated these deposits, the largest of which are found in the Green River formation of northwestern Colorado and northeastern Utah. These areas have been mapped out, their depths and length have been measured, and crude field tests have been made along the lines of distillation. The shales on distilling yield petroleum, the amount depending largely on the richness in hydrocarbons of the shales, which varies in different localities.

In the United States Geological Survey Press Bulletin for December, 1916, it is stated that 20,000,000,000 barrels of crude oil could be obtained by distilling such shale deposits ranging over 3 ft. in thickness in Colorado alone. This would yield in the neighborhood of 2,000,000,000 barrels of gasoline, an item of considerable importance. At present the Bureau has in press a report giving the results of the exploration, the tests made on the shales and an account of experiments made to determine the possible gasoline production, both by the ordinary commercial processes and by the Rittman process. This report should prove of great interest to gasoline producers and users.

The oil produced from some of these shales is dark brown in color, rather mobile, and has a dominant odor of the lighter hydrocarbons. The extent to which these latter are present may be judged from a sample kept in the writer's office. On receiving that sample directly from the source of distillation, it was put in a bottle and stoppered very tightly with an ordinary cork. After standing for three weeks the oil had become very viscous, had very little odor due to the lighter hydrocarbons, the main odor now being that typical of the product left on distilling ordinary petroleum for the lighter and more volatile constituents. This certainly seems to indicate that the percentage of volatile constituents is very high, which is a promising asset for the production of gasoline.

South Africa seems to offer another possible source for gasoline from bituminous shales. According to the *South African Mining Journal*, Aug. 19, 1916, page 460, such bituminous shales should not occur in metamorphic rocks, because any severe metamorphism destroys these shales. Bituminous shales are known to occur in the Black Shale group in Rhodesia. This deposit lies in the region of the Wankie Main coal fields. Other possible localities in South Africa are the main belt which stretches in a northeastern and southwestern direction through the Wankie and Sebungwe districts. This belt in the northwest expands and includes most of the country between the Great Escarpment and the Zambesi River, the northernmost portions of the Lomagundi district, the Sabi coal field in the Ndanga district and the Umzingwane and Massabi fields in the Gwanda district. An interesting article on the occurrence of oil shales in Natal is found in the Oct. 28, 1916, number of the *South African Mining Journal*, by Alexander L. du Toit. Du Toit states that he has examined shales which produced 27.1 gal. of crude oil per ton of shale. On the other hand, reports have it that shales giving a far greater amount of crude oil have been tested.

Some general information regarding these shales may be of interest. Rich oil shale is very tough, burns on ignition and resists, to a remarkable extent, erosion.

On weathering these shales take on a bluish white color. A good oil shale should be dense in structure and flatten out to an adhering mass on pressing a small piece with the blade of a knife.

An item of interest in this country is that the Colorado oil shales yield a crude oil which gives 10 to 15 per cent gasoline by ordinary methods of refining. Furthermore, with little more investment 300,000,000 tons of ammonium sulphate could be derived from the Colorado shales. This product is of exceptional value as a fertilizer. The equipment for a plant handling these shales would be rather high, and comprise buildings, retorts, condensers, refining machinery and mining machinery. As in many other industries, the oil shale industry on a small scale would in all probability not pay.

Company Reports

The annual report of the *Buffalo Mines, Ltd.*, for the period commencing with May 1, 1915, and ending with April 30, 1916, shows that the mill treated 38,157 tons. Of this 30,079 tons were treated by wet concentration, averaging 19.8 ounces of silver per ton, with a recovery of 431,512 ounces, and 8078 tons were treated by combination concentration and oil flotation, averaging 25.46 ounces of silver per ton, with a recovery of 197,601 ounces. The cyanide plant treated 6340 tons of slime from the concentrator, averaging 10.54 ounces of silver per ton, of which 55,161 ounces were recovered. The total silver recovery by mill and cyanide was 684,274 ounces.

The amalgamation plant and refinery treated 13,465 lb. of high-grade directly from the mine, 285,554 lb. jig concentrates, 718,240 lb. table concentrates, 1952 lb. of metallics from the low-grade mill and 6662 lb. of precipitates from the cyanide plant. The total silver treated at the refinery was 812,020 ounces, part of which was at hand at the beginning of the year. The total bullion produced by this plant was 775,253 ounces of bullion and 4070 ounces scrap on hand giving a grand total of 779,323 fine ounces recovered, with residues still to be treated. The total production of silver, including sales of silver, silver on hand and unsettled for at smelter is 705,055 ounces.

The ore reserves are 8000 tons of broken ore ready for extraction, 5000 tons unbroken ore, 5000 tons of ore on the surface ore dumps, averaging about 18 ounces of silver; 300,000 tons of concentrator tailings containing 1,600,000 ounces of silver and 3000 tons of residues from the treatment of high-grade ore containing, besides silver values, cobalt, nickel and arsenic.

Experimental work has been conducted on the residues and tailings with very satisfactory results. Due to these results it has been decided to convert the mechanical concentrator to that of flotation. The flotation plant under construction will have a daily capacity of 600 tons. This tonnage will be distributed as follows: 450 tons of tails and 150 tons mine run ore.

Subsidiary Companies of the Tonopah Mining Company of Nevada.—The *Tonopah Placers Company*, operating at Breckenridge, Col., put two dredges in operation, one in March and one in May, 1915. Their operation was continued until December of the same year, at which time they were shut down on account of cold weather and for necessary repairs. During the past year the indebtedness of \$93,750 contracted by the purchasing of the property was paid off. An initial dividend of 5 per cent was paid in December.

At the *Eden Mining Company*, operating in Nicaragua, C. A., due to litigation, the completion of the

power plant and railroad has been greatly delayed, but at present the work is being rapidly prosecuted. During the past year the machinery for the mill was purchased. The erection of the buildings and installation of the machinery are now being carried on as fast as possible. J. L. Phillips has been elected general superintendent in charge of this property.

Work has been continued on the properties of the *Mizpah Extension Company* and *Tonopah and California Gold Mining Company*, at Tonopah, Nev. A settlement has been made with the Tonopah Extension Mining Company for the ore mined within the boundaries of the property of the Tonopah Mining Company of Nevada.

Chemistry at the Meeting of the American Association for the Advancement of Science

Symposium on the Structure of Matter

The structure of matter was the subject of a very interesting symposium at a joint meeting of the sections on physics and chemistry of the American Association for the Advancement of Science with the American Physical Society, the American Chemical Society, and the American Electrochemical Society, held at Columbia University on Wednesday, Dec. 27, 1916.

The chairman, Prof. Julius Stieglitz, referred in his introductory remarks to the wonderful strides made in recent years in the development of the theory of matter. The old alchemist's dream of transmutation has come true.

Prof. R. A. Millikan of the University of Chicago reviewed the epoch-making researches of J. J. Thomson, Rutherford, Lorentz, De Broglie and others, and emphasized the fact that radiation phenomena have been most instrumental in clearing up our understanding of the structure of matter. Barkla on the basis of his experiments calculated the number of electrons in the atoms of various elements and found this to be approximately equal to one-half the atomic weight. Undoubtedly among the most important contributions to the theory of the structure of the atom are those of Moseley. His work, too, was based on radiation. He found that the vibration frequency of an element increases as the atomic weight increases. Professor Millikan showed a number of new slides which illustrated in striking fashion the shifting of the two characteristic lines of an element toward the violet end of the spectrum upon passing from element of a lower to a higher atomic weight.

Prof. Gilbert N. Lewis of the University of California took exception to some of the theories of the structure of the atom which had been advanced in recent years, and pointed out that it was difficult to apply some of the modern conceptions to many of the organic molecules. He then briefly referred to his theory of polar and nonpolar molecules (*Jour. Amer. Chem. Soc.*, 1916, p. 762). In the polar molecule the electrons move in such a way as to tend to separate the molecule into positive and negative parts, whereas in the nonpolar molecule the electrons do not move far from their original or normal positions. We cannot apply many of our familiar physical laws to the behavior of electrons and atoms; so, for example, Coulomb's law of inverse squares does not hold true at very small or atomic distances. We ought to try to preserve, however, the main body of the electromagnetic theory.

Prof. Robert W. Wood of Johns Hopkins University next read a paper on "molecular resonance and atomic

structure." He described an experiment in which he passed white light through sodium vapor and showed that light was absorbed by the vapor, but partially re-emitted. Sodium vapor will re-emit the D₁ line much more readily than the D₂ line. Iodine vapor has about 120 lines between the D₁ and D₂ lines, and a single one of these can be stimulated. If we excite the iodine vapor with the yellow line of the mercury vapor we get a different grouping of the doublets. Experiments seem to indicate that there is a resonator in the sodium or iodine molecule which does not obey Hook's law.

Wm. D. Harkins, professor of chemistry of the University of Chicago, had chosen for his topic "the evolution of the elements as related to the structure of the nuclei of atoms." With the aid of a number of tables he showed that the atomic weights of the first twenty-seven elements, beginning with helium, are not multiples of the atomic weight of hydrogen by a whole number, as they would be if Prout's original hypothesis in its numerical form were true. However, when these atomic weights are examined critically it is found that they differ from the corresponding whole numbers by a nearly constant percentage difference, and that the deviation is negative in sign, with an average value of -0.77 per cent. This percentage difference has been called the "packing effect," and it represents the decrease of weight and presumably the decrease of mass, which must take place if atoms are complexes built up from H atoms.

The magnitude of the packing effect for helium is 0.77 per cent, so that if a more complex atom is built up of helium groups alone then, in general, nearly all of the packing effect is due to the primary formation of the helium nucleus from four hydrogen nuclei and two negative electrons, and almost no packing effect results from the aggregation of these helium nuclei into more complex atoms.

Professor Harkins described at some length how all the elements might be considered complex helium or helium-hydrogen atoms. He then proceeded to point out that the elements with even multiples of helium or helium and hydrogen are most prevalent.

A second paper by Prof. William D. Harkins of the University of Chicago discussed "the abundance of the elements in relation to the hydrogen-helium structure of the atoms."

According to the theory already presented in a number of papers the atoms of all the 91 elements of our ordinary system heavier than hydrogen are built up as intra-atomic (not chemical) compounds of hydrogen. The first of these 91 elements, helium, is the second in the system, and therefore has the atomic number 2. It has an atomic weight of 4.00, and may be considered to be composed of 4 hydrogen atoms. The element of atomic number 3, lithium, has an atomic weight of about 7. Now it has been found that in general among the elements of low atomic weight, the elements of even atomic number, beginning with helium, seem to be built up from helium atoms, and therefore may be said to have the general formula $n\text{He}'$, where the prime is added to indicate that these elements are intra atomic, not chemical, compounds. The odd numbered elements, beginning with lithium, seem in general to have the formula $n\text{He}' + \text{H}_2$. Thus the elements seem to fall into two series which may be called the *even* and the *odd* series, or the helium and the lithium series, if each series is named for its first member. However, it should be noted that while the formula for the helium series is $n\text{He}'$, that for the lithium series is not $n\text{Li}'$.

If the theory is correct it might be expected that some characteristic of the elements could be found, with respect to which there is a difference from odd to even and from even to odd, or in other words, the elements should show variations in periods of 2 elements each.

In order to have a basis for the comparison of the elements in the study of this problem there has been constructed in space a periodic model of which Fig. 1 is a drawing. In this model the elements are represented by balls strung on a spiral in the order of their atomic numbers,

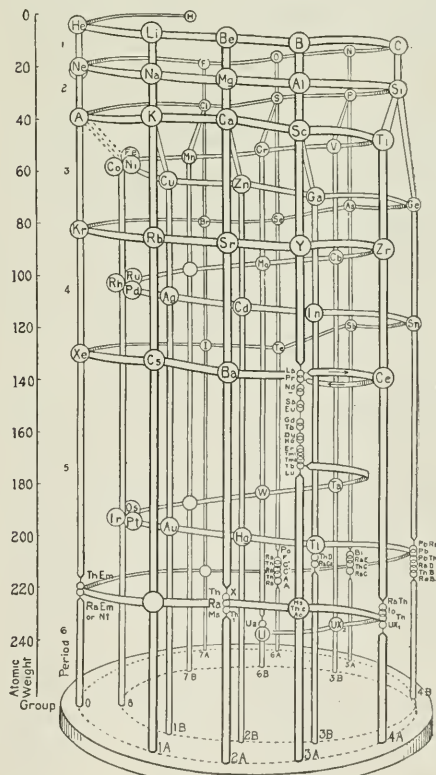
which have recently been found to be much more characteristic of the elements than their atomic weights. The spiral is so arranged that the balls representing the elements belonging to one group and having the same maximum valence are strung on the same vertical rod. The balls are set at such heights that the vertical distance from the top down represents the atomic weight. This is essential, for otherwise the different kinds of atoms of one element, called by Soddy "isotopes," cannot be represented. Thus in the lower right-hand part of the table, on the lower part of Group 4B, the element lead is represented by 6 isotopes, with the atomic weights listed, as follows: lead from radium (uranio-Pb), 206.1; lead, 207.2; lead from thorium, 208.1; radium D, 210.1; thorium B, 212.1, and radium B, 214.1. Thus the different kinds of lead, which seem identical chemically and give the same spectrum, have atomic weights which differ by as much as 8 units, or by 4 per cent. However, all of these isotopes have the same atomic number, 82, or according to the theory developed by various investigators, they have the same positive nuclear charge.

When arranged in this form of periodic table the elements other than hydrogen and helium are found to arrange themselves in periods as follows:

1. First short period	... Li	— Ne: 8 = 2×2^2 elements	{ Cycle
2. Second short period	... Na	A: 8 = 2×2^2 elements	{ 1 = 4
3. First long period	... K	Kr: 18 = 2×3^2 elements	{ Cycle
4. Second long period	... Rb	Xe: 18 = 2×3^2 elements	{ 2 = 6
5. First very long period	... Cs	Nt: 32 = 2×4^2 elements	{ Cycle
6. Second very long period	Eka	Cs: — (incomplete)	{ 3 = 8

It is thus seen that these periods and cycles make up a numerical system of a remarkably simple form, and it seems evident that this system must express something inherent in the structure of the atoms. However, what it is desired to emphasize here is that nearly all of the physical properties of the elements vary in periods which are either the same or nearly the same as these. The chemical properties also vary in rather long periods, which in the case of the short periods 1 and 2, are identical with those given.

From this it is seen that both the chemical and the phys-



Periodic Table by W.D. Harkins

ical properties of the elements vary in periods which are long in comparison with the change in periods of 2 elements as indicated by the division of the elements into the odd and even series. If now neither the physical nor the chemical properties vary according to these extremely short periods, what, it may be asked, is left which can so vary?

Now it might easily be shown that the hydrogen-helium system of the structure of the elements, which divides them into the odd and even series, is in reality more directly applicable to the structure of the nuclei of the atom than to the atom as a whole. If then the Rutherford theory that the nuclei of atoms are extremely minute, is used as a basis for reasoning, it would be expected that the variation in the structure of the nuclei should not cause variations in the properties of the elements except in so far as they influence the nuclear charge. This nuclear charge has been assumed to be equal to the atomic number, and therefore rises with perfect regularity from odd to even or from even to odd. It seems probable that the number of electrons external to the nucleus is equal to the nuclear charge, and that it is the change in their number and arrangement which causes the physical properties to vary according to the periods listed above. This question has been discussed in a previous paper. (Jour. Am. Chem. Soc., Vol. 38, pp. 186, 203, 281.)

It might be expected, however, that the composition of the nucleus should affect its own stability, which from radioactive evidence means the stability of the atom. From this standpoint it might be reasonable to suppose that the atoms of one of the series, the even or the odd, should be more stable than those of the other. Now unfortunately there is no known method of testing the stability of the lighter atoms, but it might seem, at least at first thought, that the more stable atoms should be the more abundantly formed, and to a certain extent this is undoubtedly true. If then, at the stage of evolution represented by the solar system, or by the earth, it is found that the even numbered elements are more abundant than the odd, as seems to be the case, then it might be assumed that the even numbered elements are on the whole the more stable. However, there is at least one other factor than stability which must be considered in this connection. The formula of the even numbered elements has been shown to be $n\text{He}$, which may be written $n(4\text{H}^+)$. Now, since the formula for the odd numbered elements is $n\text{He} + \text{H}$, or $n(4\text{H}^+) + \text{H}^+$, it is evident that, if the supply of H , needed by the elements was relatively small at the time of their formation, not so much material would go into this system. This would be true whether the H represents three atoms of hydrogen or one atom of some other element. With regard to the latter alternative, it is at least remarkable that the H , occurs 11 times in the system for the first 27 elements, while H_2 and H each occur only once, and it may also be mentioned that Fabry and Buisson⁴ have by interference methods determined the atomic weight of nebium to be 2.7, and this they think indicates that its real atomic weight is 3. Also, Campbell has found that in the nebula N. G. C. Index 418, situated in the southern part of the constellation of Orion, the nebium spectrum is found farther from the interior than that of helium, while the hydrogen spectrum extends out to a much greater distance still. This, he thinks, indicates that the atomic weight of nebium lies between the values for hydrogen (1) and helium (4).

In studying the relative abundance of the elements the ideal method would be to sample one or more solar systems at the desired stage of evolution, and to make a quantitative analysis for all of the 92 elements of the ordinary system. Since this is impossible, even in case of the earth, it might be considered that sufficiently good data could be obtained from the earth's crust, or the lithosphere. However, it seems probable that the meteorites represent more accurately the average composition of material at the stage of evolution corresponding to the earth than does the very limited part of the earth's material to which we have access. At least it might seem proper to assume that the meteorites would not exhibit any special fondness for the even numbered elements in comparison with the odd, or vice versa, any more than the earth or the sun as a whole, at least not unless there is an important difference between these two systems of elements, which is just what it is desired to prove.

A preliminary study of the most recent analyses of meteorites of different classes showed that, either for any one class or for the meteorites as a whole the even numbered or helium system elements are very much more abundant than those of the odd numbered or lithium system. For a more detailed study use was made of the data collected by Farrington,⁴ who suggests that the average composition of meteorites may represent the composition of the earth as a whole.

The results obtained by averaging the analyses of 318 iron and 125 stone meteorites, 443 in all, show that the first seven elements in order of abundance are iron, nickel, silicon, magnesium, sulphur, and calcium; and not only do all of these elements have even atomic numbers, but in addition they make up 98.6 per cent of the material of the meteorites. Of the remaining elements present to a great enough extent to have an appreciable effect upon the percentage values, 7 are odd and 5 are even, but in all only 1.22 per cent or odd numbered, while 98.78 per cent are even.

Of the iron meteorites 99.22 per cent of the material is made up of even numbered elements, and of the stone meteorites, 97.50 per cent. While the results for the earth's lithosphere are not so striking, they still show the same general tendency very strongly; for, of the six most abundant elements, only aluminum is odd numbered, and the elements of even atomic number make up about 86 per cent of the material. The only odd numbered elements other than hydrogen present in the lithosphere in amounts over 0.2 per cent are aluminum, sodium, and potassium.

Table 1 gives the average composition of iron and stone meteorites, arranged according to the periodic system. The numbers before the symbols represent the atomic numbers and the numbers underneath give the percentage of the element. It will be noted that the even numbered elements are in every case more abundant than the adjacent odd numbered elements. The helium group elements form no chemical compounds, and are all gases, so they could probably not remain in large quantities in meteorites. For this reason, and also because the data are not available, the helium or zero group is omitted from the table. The only criticism which could be made of the system of averaging, which is that of including all accurate analyses, is that it that it places undue emphasis upon the iron as compared with the stone meteorites. However, since the two relations shown in Table 1 are true for each class of meteorites separately it is evident that they will be true whatever system of averaging may be chosen.

TABLE I—AVERAGE COMPOSITION OF METEORITES ARRANGED ACCORDING TO THE PERIODIC SYSTEM

Series	Group Odd 1	Group 2 Even	Group 3 Odd	Group 4 Even	Group 5 Odd	Group 6 Even	Group 7 Odd	Group 8		
								Even	Odd	Even
2				6C 0.04%		8O 10.10				
3	11Na 0.17%	12Mg 3.80%	13Al 0.39%	14Si 5.20%	15P 0.14%	16S 0.49%				
4	19K 0.04%	20Ca 0.46		22Ti 0.01		24Cr 0.09	25Mn 0.03	26Fe 72.06	27Co 0.44	28Ni 6.50
	29Cu 0.01									

If attention is now turned to the heavier elements as shown in the model, it is seen that the five unknown elements eka-caesium, eka-manganese 1, eka-manganese 2 (dwi-manganese), eka-iodine, and eka-neodymium, have odd atomic numbers. (There is some doubt as to the discovery of thulium 2.) Not only are the unknown elements odd numbered, but among the radio-active elements, if the most stable isotope of each element is used for the comparison, the odd numbered elements are much less stable than the adjacent elements of even number.

If we consider the rare-earths—the elements which are most similar chemically, while at the same time their atomic numbers change in steps of one—the same result is ob-

TABLE II

Atomic Number	Abundance	Element	Atomic Number	Abundance	Element
55	e	Caesium	63	rr	Europium
56	ccc	Barium	64	r	Gadolinium
57	e	Lanthanum	65	rrr	Terbium
58	cc	Cerium	66	r	Dysprosium
59	r	Praseodymium	67	rrr	Holmium
60	e	Neodymium	68	r	Erbium
61	rrr	Unknown	69	rr	Thulium
62	e	Samarium			

tained. In table 2, which includes, besides the rare-earths a number of elements adjacent to them, the latter *c* indicates common in comparison with other elements in the table, and *r* indicates rare; *cc* represents very common, etc. The comparison is only a rough one, but it is sufficiently accurate for the purpose for it indicates that in every case the even numbered element is more abundant than the adjacent odd numbered element.

The above results may be summarized by the statement that in the evolution of the elements much more material has gone into the even numbered elements than into those which are odd, either because the odd numbered elements are less stable, or because some constituent essential to their formation was not sufficiently abundant, or both.

It is easy to see too that most of the material has been used up in the formation of the lighter elements. Table 2 shows that in the meteorites the most abundant elements are oxygen in series 2, the elements of series 3 except neon, and the members of the first eighth group tried (iron, cobalt, nickel). Clarke has found that just these same elements are the most abundant in the lithosphere, although in the lithosphere potassium and calcium in series 4 are also moderately abundant. If the lithosphere were considered alone it might be considered that the abundance of these elements is due to changes which have taken place in the lithosphere, or to the rising to the surface of the lighter elements, but these objections are not so valid when the meteorites are found to show the same relations.

In the three classes of material, the lithosphere, the stone meteorites, and the iron meteorites, in spite of variations in density from 2.5 to 8, the same two rules are found to hold, that (1) the even numbered elements, and (2) the elements of low atomic number and low atomic weight, are the elements which occur in abundance.

If an artificial line of division is made so as to classify the first 29 elements as of low atomic number and atomic weight, and the remaining 63 elements as of high atomic weight, then the following table, based upon data from analyses listed by Farrington and Clarke may be presented to emphasize the importance of the former class.

TABLE III—PROPORTION IN VARIOUS MATERIALS OF THE ELEMENTS OF LOW ATOMIC NUMBERS

Material	PERCENTAGE OF ELEMENTS WITH ATOMIC NUMBERS	
	1-29	30-92
Meteorites as a whole	99.99	0.01
Stone meteorites	99.98	0.02
Iron meteorites	100.00	0.00
Igneous rocks	99.85	0.15
Shale	99.95	0.05
Sandstone	99.95	0.05
Lithosphere	99.85	0.15

It may be said that, so far as the abundance of the elements goes, the system seems to play out at the end of the first eighth group in the periodic system. It may be of interest to note here, what has been pointed out in former papers, that it is just at this point in the system that the atomic weights cease any longer to be very close to whole numbers, as they are for the lighter weight elements. Also just at this point the exact formula given for the elements ceases to hold well. These facts do not mean, however, that the system fails beyond the iron group of elements; for it is just among the heaviest elements that it received its verification by the actual decomposition of the elements into helium.

Dr. Wm. J. Humphreys of the U. S. Weather Bureau, Washington, reviewed the history of "the relation of magnetism to the structure of the atom." He emphasized that it was the Zeeman effect that had verified the hypothesis of the existence of the electron, and had shown beyond a doubt that electrons are common constituents of all atoms.

Prof. Albert P. Wills of Columbia University in his paper on "the relations of magnetism to molecular structure" pointed out that the magnetic properties of gases had not been investigated thoroughly as yet, and offered a very interesting field for research.

Dr. Irving Langmuir of the General Electric Co., Schenectady, N. Y., read a paper on "the structure of

solids and liquids." He had found that in the case of a tungsten-thoria filament the surface film was 1 atom deep. In general, we can conclude that the substance on the surface decides more or less how the substance as a whole is going to behave. (See Nichols' medal paper, this journal, Vol. 13, p. 244, 1915.)

DISCUSSION

Prof. Wm. Duane of Harvard referred to the remarkable results recently obtained by the use of X-rays, and discussed the determination of wave lengths of X-rays.

In the absence of Prof. J. M. Nelson of Columbia, Dr. K. G. Falk presented his note on "chemical valence and the Grignard reaction." Dr. Falk also presented Prof. L. W. Jones' paper on "a case of chemical isomerism resulting from a difference in distribution of valence electrons."

E. D. Adams pointed out that where our knowledge is still very meager is in regard to the relation between electricity and matter.

Albert C. Crehore discussed the action of one electron upon another. Professor Swan in his usual animated style discoursed on the analysis of a single electron. Prof. A. G. Webster gave a brief summary of our present knowledge of the structure of the atom and was delighted to see the chemists and physicists get together on this most vital subject.

Professor Pupin closed the discussion, emphasizing that he was glad to see the introduction of a rotary electron into our theories. He favored rotation for years. At present we are literally swamped with new theories of the structure of the atom, but sooner or later the various ideas advanced by physicists and chemists from all over the world would be brought together into one co-ordinate whole.

Chemical Session

The chemical session of December 28 was held at the College of the City of New York, Professor Julius Stieglitz being in the chair. Dr. Phoebus A. Levene of the Rockefeller Institute spoke on "the individuality of tissue elements." Within recent years there have been three great achievements in clearing up the relation between chemical structure and the phenomena of life.

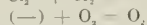
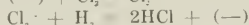
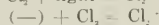
First, is the discovery of Dr. Loeb that the permeability of membranes of cells to potassium salts is not a constant, being dependent upon the concentration of the potassium salts. Second, is the discovery that the function of growth is a function of amino-acids having a very definite structure. Third, is the discovery that there is a specificity peculiar to species (hereditary) acid a specificity of mendelian nature (color, etc.).

There are three distinct classes of chemical compounds now known to biologists: (1) The nucleic acids, which occur everywhere, are indispensable to growth, but are not carriers of individuality. (2) The hormones, which are the carriers of Mendelian characteristics. (3) Proteins, the carriers of heredity of species. Our knowledge of these is still very incomplete.

Prof. William McPherson of Ohio State University discussed "asymmetric syntheses and their bearing upon the doctrine of vitalism." He reviewed the work of the early investigators, Wöhler, Pasteur, Wislicenus, Van't Hoff, and others. We still lack a good explanation of the fact that nature's products, such as sugars, are always active, either *d* or *l*, whereas our laboratory products are, as a general rule, inactive. A number of "explanations" have been offered, but the underlying

reason for this difference between the natural and artificial products is still not thoroughly understood.

Dr. Hugh S. Taylor, Princeton University, discussed "the photochemistry of the chlorination processes." This was a theoretical paper, based on observations made by the author in the Bodenstein laboratory at Hannover a few years ago. The general formulas may be written as follows, $(-)$ meaning an electron:



It is necessary that both the chlorine and the hydrogen are exposed to the light rays simultaneously.

Dr. Saul Dushman of the General Electric Co., Schenectady, N. Y., discussed the "application of atomic theories in chemistry." He discussed statistical mechanics, law of probability, Brownian movements, and Maxwell's distribution law.

Dr. Geo. F. Kunz made a brief announcement regarding the chemical preparedness exhibit at the Museum of Natural History.

Professor Stieglitz then asked Dr. Herty to take the chair. Dr. Herty read a telegram just received from Secretary Parsons stating that Professor Stieglitz has been elected president of the American Chemical Society, to succeed Dr. Herty.

Prof. M. T. Bogert of Columbia University discussed "the National Research Council." He gave a brief outline of the aims and purposes of the Council, emphasizing that the Council was not going to direct research, but merely aid. Ten thousand dollars has already been subscribed for the maintenance of a central office, where information of a scientific nature will be obtainable. He concluded with reading the names of the members of the Council.

Dr. C. G. Derick, Buffalo, discussed "equilibrium constants and chemical structure." He demonstrated how the principles of physical chemistry, when applied to organic chemistry, are productive of very important results. As a typical example, he recited his experiment on esters. If the ionization constant for acetoacetic-ethyl ester is K_a , that of acetylacetone K_a , and that of benzoyl acetic ethyl ester K_a , then

$$K_n = \frac{k_1 \times k_2}{k_n}$$

The calculated values for k_n are 0.246 (25°) and 0.234 (40° C.), whereas the values determined by actual measurement are 0.287 and 0.233 respectively.

Dr. F. G. Wiechman discussed the "increased sugar content of the sugar beet after removal from the soil." Due to the action of enzymes, a part of the starch in the beet will be transformed into sugar after the tops have been removed. Wiley and Maxwell (1893) had found an increase of 14.2 per cent. Similar results were obtained with barley in Germany. Wiechman has applied this principle practically. In one of the first tests, 500 lb. of beet cosettes were stored at a temperature of 132 deg. F. The net increase after seven days was 5.31 per cent in the sugar content of the cosettes.

Dr. Edgar Graham discussed "conductivity measurements in oxidation and reduction reactions." In the determination of the acidity of wines, etc., where ordinary indicators fail, Graham has found that conductivity measurements gave very reliable analytical results. Upon the gradual addition of standard alkali solution the conductivity (due principally to the H ion) of the solution dropped very rapidly until the end point

was reached. Further addition of alkali did not alter the conductivity values very much. By plotting the values the end point can readily be located.

M. L. Crossley discussed "valency and valence." Valency is the result of chemical reactions. For example, in the reaction



CH_3 (in CH_3Cl) has a valency of one as a result of the reaction. The paper brought out animated discussion by Messrs. Dushman and Taylor. Dushman objected seriously to the term "dynamic instability" which Crossley had used.

Prof. Gustav Egloff and R. J. Moore of Columbia University, discussed "decomposition of paraffine hydrocarbons." As we proceed from the low fractions C_1 - C_2 , C_3 - C_4 , and C_5 - C_6 to the higher boiling fractions we find that at a certain temperature, e. g. 700 deg. Centigrade the C_{12} - C_{15} fraction is more stable than those immediately preceding or following.

On Thursday evening a session was held at the Museum of Natural History, where Prof. Arthur A. Noyes presented a paper on the fixation of nitrogen. He gave an outline of the successful processes, figures on annual consumption, and data on utilization in arts and industries.

A reception in Philippine Hall closed the chemical meeting.

American Physical Society

Meetings of the American Physical Society, jointly with the A. A. A. S., were held on Tuesday, Thursday and Friday, Dec. 26, 28, 29. Among the forty papers presented, the following will be of particular interest to our readers:

S. Leroy Brown, University of Texas, A new calorimetric resistance thermometer.

Arthur S. King, Mt. Wilson Solar Observatory, California, Experiments with the electric furnace on the anomalous dispersion of metallic vapors.

P. W. Bridgman, Harvard University, The effect of pressure on the resistance of metals and a possible theoretical explanation.

H. L. Dodge, State University of Iowa, The effect of temperature upon the Young's modulus of tungsten wire.

A. W. Hull, Schenectady, N. Y., The internal structure of the atom.

The address of the retiring chairman of Section B (Physics) of the A. A. A. S., Dr. A. Percival Lewis, University of California, dealt with "recent progress in spectrometry," with special reference to its relations to the structure of matter. It is published in full in *Science*, Dec. 29, 1916.

Program of Meeting for Presentation of Perkin Medal

The New York Section of the Society of Chemical Industry will hold its meeting for the award of the Perkin Medal to Dr. Ernst Twitchell on Friday evening, Jan. 19, at the Chemists' Club. The program is as follows:

Introductory Remarks	The Chairman
Presentation of the Perkin Medal and Address	Charles F. Chandler
Acknowledgment by the Recipient	Ernst Twitchell
The Twitchell Process in the Glycerin Trade	A. C. Langmuir
The Twitchell Process in the Soap and Candle Industry	Martin H. Ittner

The Niagara Power Situation

The following joint resolution, authorizing the Secretary of War to issue temporary permits for additional diversions of water from the Niagara River, has been passed by the House of Representatives:

"Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, that the Secretary of War be, and he is hereby authorized to issue permits revocable at will for the diversion of water in the United States from the Niagara River above the falls for the creation of power, to individuals, companies, or corporations which are now actually producing power from the waters of said river, in additional quantities, which, with present diversions, shall in no case exceed the capacity of the generating machinery of the permittee and tenant companies now installed and ready for operation, nor an amount sufficient to enable the permittee to supply the now existing hydroelectric demands of the individuals, companies, or corporations which said permittee and tenant companies are now supplying, but not in excess of the capacity of power-using appliances of said consumers now installed and ready for operation: *Provided*, that in no event shall the total quantity of water diverted in the United States from said river above the Falls for power purposes exceed in the aggregate a daily diversion at the rate of 20,000 cubic feet per second: *And provided further*, that this resolution shall remain in force until the fourth day of March, nineteen hundred and seventeen, and no longer, at the expiration of which time all permits granted hereunder shall terminate, unless sooner revoked; and nothing herein contained shall be held to confirm, establish, or confer in or upon any such permittee any right in or to the water which he is now diverting or which he may be authorized to divert hereunder."

The words in italics are the amendments the Senate would not agree to (the Senate proposing "the first day of July" instead of "the fourth day of March"). This throws the whole proposition into a conference committee of the Senate and House.

* * *

Representative Huddleston has introduced a bill (H. R. 19733) proposing a Niagara Power Commission of three members subject to the general supervision of the Secretary of the Interior. The salary to be \$6,500 for the chairman and \$6,000 for each of the other two members. Its business is to be the production of hydroelectric energy from waters diverted from the Niagara River and its distribution. The power is to be limited to the limit fixed by the treaty between the United States and Great Britain.

"The said Niagara Power Commission shall transmit and distribute, in the United States only, hydroelectric energy to municipalities and consumers convenient to its works and lines, justly and without unreasonable discrimination and as nearly as may be at the cost of delivery plus reasonable charges to cover the expenses of its operations, including the salaries of the commissioners, and plus such further annual charges as will be reasonably sufficient to discharge all of the obligations of said Niagara Power Commission so as to leave same free from debt at the end of a period of fifty years: *Provided*, That no distribution or sales of electric energy shall be made for consumption within the corporate limits of any municipality which may be able, willing and ready to assume the distribution of same therein.

"Said Niagara Power Commission shall use said waters at an efficient head and with reasonable economy, and shall pay into the Treasury of the United States for all hydroelectric energy which may be gen-

erated from said waters at the rate of \$1 per annual horsepower, and no taxes shall be levied upon or collected from it by any State on account of the rights and franchises granted hereby.

"Said Niagara Power Commission may contract with one or more concerns now using said waters for generating hydroelectric energy for supplying said Commission with such energy for not exceeding five years next after the approval of this Act at a reasonable charge, not exceeding \$15 per annual horsepower, such energy when so supplied to be distributed by said Niagara Power Commission as provided by Section 6 of this Act.

"No waters shall be diverted in the United States from said Niagara River above, at, or below the Falls thereof for the purpose of generating hydroelectric energy except by said Niagara Power Commission, and each act of such diversion shall constitute an offense and be punishable by fine of not more than \$5,000: *Provided*, that said Niagara Power Commission may license and authorize such diversion for not more than five years after the passage of this Act for an annual charge or fee of not less than at the rate of \$75 per cubic foot-second.

The Tariff and the Business Commissions

Edward N. Hurley, chairman of the Federal Trade Commission, has resigned from that body, to take effect Feb. 1, with the result that there are now practically two vacancies on the commission which the President must soon fill. Commissioner Rublee has never been confirmed by the Senate, because Senator Gallinger has said Mr. Rublee is "personally obnoxious" to him, Senatorial courtesy allowing the Senator from New Hampshire to prevent the confirmation.

In this connection it is reported in Washington that President Wilson is considering the names of a number of men who would make suitable appointees on both the Federal Trade Commission and the new Tariff Commission, and that he may be expected to announce the names of the latter commissioners shortly. Almost the same type of man is wanted for both commissions.

There is much speculation in Washington concerning the prospective commissioners on these two bodies, and in regard to tariff matters. Secretary McAdoo and the Ways and Means Committee of the House are searching for many additional articles to tax, in the form of tariffs or otherwise, owing to the big deficit in the public funds. The tariff commission when appointed will have much to say on these matters. It was proposed in Washington Wednesday that a tax be placed on business profits in excess of an 8 per cent dividend. This would be a tax of 5 per cent and would yield, it is estimated, about \$200,000,000. Among other items which the Secretary of the Treasury and the Ways and Means Committee of the House are considering are the following: One dollar per horsepower on internal combustion engines, automobiles, \$30,000,000; an output tax on petroleum, copper, aluminium and pig-iron, by the pound, \$81,000,000; 10 per cent on crude rubber, \$15,000,000.

There is a movement on foot in Washington to bring about a method of commissioners serving permanently as chairmen of their bodies, rather than to have the office of chairman rotate as is done in the Interstate Commerce Commission and as was recently done in the Federal Trade Commission. There is a feeling among some public men that the chairman of every Federal commission should be designated by the President. It is claimed that no private corporation could be run successfully without a single and fairly permanent directing head.

The movement to have chemistry represented on the Tariff Commission which we heartily recommended editorially in our issue of Dec. 1, 1916 (page 611), is spreading. Mr. Ellwood Hendrick who had been recommended to President Wilson for a place on the commission by the directors of the American Chemical Society and of the American Electrochemical Society, has since been also endorsed by the Chemists' Club, the American Institute of Chemical Engineers, the Manufacturing Chemists' Association of the United States, the American Pharmaceutical Association, the National Wholesale Druggists' Association, the National Association of Manufacturers of Medicinal Products, and the Technical Association of the Pulp and Paper Industry.

Some Production Statistics for 1916

Gold.—The gold production for 1916 as estimated by the Geological Survey was 4,465,807 fine ounces valued at \$92,316,400, which is a decrease of \$8,719,300 from 1915. California was the leading producer, with over 1,000,000 ounces. Colorado and Alaska were the next in importance, Colorado being but little behind California.

Silver.—There were produced in 1916 about 74,961,000 fine ounces of silver, being a decrease of 2,077,275 fine ounces, according to the Geological Survey. There was, however, an increase in value of \$10,560,000, the average price being \$0.658. Montana was the leading producer, with Nevada, Utah and Idaho running close in the order named.

Copper.—A new record was established in the production of copper. The smelter output, as estimated by the Geological Survey, was 1,928,000,000 lb. and the refinery production 2,311,000,000 lb. The increase in smelter production over 1915 was 540,000,000 lb. and the increase in refinery production was 677,000,000 lb. It is estimated that with additions now being built our refineries can turn out 2,500,000,000 lb. this year if it is required. The American Metal Market Report estimates the supply on hand Jan. 1 at 82,429,666 lb. With exports of 760,000,000 in 1916 this leaves 1,633,429,666 lb. available for home consumption in 1916. Deliveries to consumers are estimated at 1,550,000,000 lb., but how much of this was actually used is not known.

Lead.—A new production was made in lead with 579,600 tons, a gain of 29,500 tons over 1915. There was a decrease of 29,000 tons in the exports of lead of foreign origin and an increase of 21,000 tons in exports of domestic lead. There were 471,200 tons available for home consumption as compared to 426,751 tons in 1915.

Tin.—The production of primary tin direct from ore became a new industry in this country in 1916. The two producers, both of which smelted foreign ore (chiefly Bolivian) turned out over 2000 tons, and the industry should become well established within another year or two. It depends, of course, upon a foreign supply of ore.

Spelter.—The production of spelter from domestic ore in 1916 was 553,000 short tons and from foreign ore 105,000 tons, according to the Geological Survey. Exports were 210,500 tons, and domestic consumption 445,000 tons. The increase in production amounted to 34 per cent, while the exports increased 59 per cent and domestic consumption 22 per cent.

Iron.—Estimates of shipments of iron ore from the mines in 1916 are 75,500,000 gross tons, compared to 55,493,100 tons for 1915. About 49,000,000 tons of

pig iron were produced, compared with 29,916,213 tons in 1915.

Quicksilver.—Quicksilver was produced to the extent of 28,942 flasks of 75 lb. each, valued at \$3,643,800. This was the greatest output since 1905. The figures show an increase of 38 per cent in quantity and 99 per cent in value over 1915.

Chromite.—Two years ago only one small mine in the United States was producing chromic iron ore. This was in Shasta County, Cal. The output in 1914 was less than 1000 long tons. In 1915 it increased to 3281 tons and in 1916 to over 35,000 tons, according to Geological Survey estimates. It comes from California, Oregon, Wyoming and Maryland. The imports were 88,801 long tons during the first ten months.

Petroleum.—Preliminary estimates of the Geological Survey indicate that 293,300,000 barrels of crude petroleum was produced and marketed in 1916. This is 4 per cent greater than the record-breaking year of 1915. It is estimated that 38 per cent came from the Oklahoma-Kansas field and 30 per cent from California.

Coke.—The coke output of the United States broke all records in 1916. More than 35,000,000 tons of beehive coke was manufactured, an increase of over 27 per cent compared with 1915, and 500,000 tons more than the record-breaking total in 1910. By-product coke amounted to 19,200,000 tons, an increase of more than 5,000,000 tons, or 36 per cent, compared with 1915. The total coke production, according to estimates, was 54,300,000 tons, an increase over 1915 of 12,700,000 tons, or 30 per cent.

Coal.—Coal production records were smashed in 1916, when the output was around 597,500,000 tons, compared with 570,000,000 tons, the previous high record established in 1913. The quantity of bituminous coal mined was 509,000,000 tons, an increase compared with 1915 of 66,500,000 tons, or 15 per cent, according to the Geological Survey. The quantity of Pennsylvania anthracite was about 88,312,000 net tons, a decrease of 600,000 tons.

Cement.—Shipments of Portland cement in the United State in 1916 approximated 94,508,000 barrels, an increase over 1915 of more than 7,500,000 barrels, the heaviest shipments in the history of the industry. Production, while it did not keep pace with shipments, reached a total of about 91,194,000 barrels, an increase of more than 5,000,000 barrels over 1915, while stocks fell off more than 3,000,000 barrels.

Lime.—Estimates indicate a total marketed production of 4,150,000 short tons of lime in 1916, or a gain of 15 per cent. This is a new high record. The marketed production of hydrated lime was 710,000 tons, a gain of more than 13 per cent.

The Chemical Industry of Switzerland

Switzerland is one of those countries which, although covered by a vast area of mountainous terrain, is exceptionally poor in all kinds of mineral resources. The main raw materials, coal and iron, are practically lacking, and necessitate their importation from the surrounding nations. Water power is, however, available and is being developed to its full capacity. Hydroelectric power plants have been and are still being built in all sections of the country, where the waters of the swiftly flowing mountain streams justify the investment. The war has to a great extent thrown this small country on its own resources as far as the power question for industrial purposes is concerned, but at the best this power source is insufficient to supply the 107 chemical

plants at present in operation in Switzerland. The bulk of the coal, therefore, at present is obtained from Germany. Previous to the war coal was also imported from France.

Switzerland is blessed with at least two universities, whose chemical engineering departments are ranked with the best in the world. These institutions are the Polytechnikum at Zurich and the University of Zurich, both being independent of one another and financed by the government. From these two main sources come practically all the chemical engineers the country has. The engineers receive their training under men like Treadwell, Lunge, Werner, Lorenz, Vislizenius and others, all prominent figures in the field of chemistry.

The most important chemical industry is undoubtedly the manufacture of synthetic dyes. Besides this branch, Switzerland manufactures pharmaceutical products and chemicals for industrial purposes. There are two types of colors produced in Switzerland, namely, vegetable dyes, chiefly produced from logwood, and coal tar colors. The most important dye industry is undoubtedly the production of synthetic dyes. At least 106 synthetic dyes are at present produced by the various dye factories of the country. These dyes at present are mainly shipped to England and France, but would, under normal conditions, be available for the American market. A list of the colors produced may be found in the Commerce Reports for Nov. 13, 1916. The importance of the Swiss dye industry is best illustrated in the following table, giving the exports since 1896, taken from the mentioned report:

Year	Coal-Tar Colors	Vegetable Dyestuff Extracts	Tanning Extracts	Synthetic Indigo
1896.....	\$2,580,754	\$94,923	\$126,770	.....
1897.....	3,186,632	117,480	147,627	.....
1898.....	3,259,539	93,156	135,323	.....
1899.....	3,172,331	81,860	143,153	.....
1900.....	2,961,173	69,576	125,347	.....
1901.....	2,847,389	65,610	123,719	.....
1902.....	3,081,563	73,871	141,673	.....
1903.....	3,326,626	76,987	146,778	.....
1904.....	3,452,436	75,732	138,064	.....
1905.....	3,862,756	73,068	160,137	.....
1906.....	4,209,646	72,038	142,803	.....
1907.....	4,233,533	75,866	139,872	.....
1908.....	3,793,836	81,538	152,419	.....
1909.....	4,667,869	94,239	183,640	.....
1910.....	4,905,002	99,142	223,334	.....
1911.....	4,920,212	154,044	297,684	\$72,460
1912.....	4,970,474	97,346	315,130	291,334
1913.....	4,794,960	95,987	323,782	754,792
1914.....	5,123,944	84,250	286,252	978,956
1915.....	5,555,738	94,261	289,144	434,525

Next in importance to the dyestuff industry is the manufacture of pharmaceutical preparations. Among the specialties made are protargol, collargol, itrol, a new preparation of a silver protein compound carrying 30 per cent silver and sold under the trade name of solargyl, airol, phytin, throcol, salen, benzalen, vioform, lipogodin, jodostarin and jodogallicin. Besides the above mentioned chemicals, the Swiss factories produce alkaloids, perfumes, cosmetics, and, for industrial purposes, acid potassium tartrate, boric acid, phosphoric acid, sodium, tanning extracts, glycerin, methyl alcohol, coal-tar derivatives, benzylchloride, glue and gelatin.

It is of interest to know that the first chemical factory in Switzerland was built in the year 1764. From that time up to date the number has increased to 107. The products produced in these factories are, under normal conditions, shipped to all parts of the world, while at the present time the export is mainly restricted to China, France, Italy and the United States.

Waste Heat for Steam Generating Purposes.—In our last issue (January 1, 1917) owing to a printer's error, the author's name, Mr. Arthur D. Pratt, was omitted from the concluding part of his article on "The Utilization of Waste Heat for Steam Generating Purposes."

The Human Side of the Development of Chemical Industry*

By G. W. Thompson

Numerous writers and speakers have called frequent attention to the great service which chemistry has rendered to humanity. In every field of industry she has been active, every product of man's labor has felt her magic touch. Modern civilization can be measured most accurately by considering the influence which chemistry has had upon industry and industrial operations. It is unnecessary here to tell what she has done. We are more concerned with the future than with the past, and judging the future by the past, the benefits which chemistry during the coming years will confer upon humanity will be infinitely valuable. On us, her votaries, is imposed the task of laying out the course of her progress, preparing and making the way easy for her and heralding her triumphant march. It is the purpose of this paper to indicate how this may best be done.

It should be perfectly obvious that the purpose of all industry is to satisfy the desires of human beings. This is as true of chemical industry as it is of any other industry. The chemist renders human service. He is a human being himself and his service to human beings makes him a part of a great democratic commonwealth in which every member is a factor in the development of the whole. The chemist is only a fraction in this commonwealth, but the more he is organically a part of it the greater is his power of service. Like everyone else he does not exist by himself alone, but is dependent for his existence upon every other human being that is a part of the social organism.

In the last analysis all of the relations between human beings are mental relations. The instruments of connection between human beings may be material, but the relation itself is spiritual. In so far as the chemist renders service he does so by impressing himself on other people and affecting them either directly through personal contact or indirectly through the products of labor in the fabrication of which he has had a part. Human relationship, therefore, is the end toward which we are perforce all compelled to work. Each man must impress other people and he must in turn be impressed by them. There is no such thing as independence. We are all dependent, and in seeking for what we may nominally call independence we are simply shifting our dependence from one point to another. It is foolish to talk about being independent and it is unwise to seek independence, because it cannot be obtained. Still more important than this, it is best for us that we should not seek independence, but that each one of us should seek to be dependent upon everyone else, thereby conforming to the best conception of human relationships and to the economic law according to which the best service only can be rendered.

What we propose, therefore, is that the chemist should strive against anything that would tend to isolate him and separate him from his fellowmen. What we will try to show is the means by which he can avoid these tendencies, how he may more effectively integrate himself into the social organization.

Perhaps what we have in mind can best be visualized by considering here what has been believed by some to have interfered with the growth of chemistry in this and other countries. For instance, the cry has come from England that technically educated men have not been sought for as the occupants of high official and

*A paper read at the Ninth Annual Meeting of the American Institute of Chemical Engineers, New York City, January 12, 1917.

business positions. It has been claimed that a scientific education did not help towards social or public advancement; that in England a man with a classical education was sought after, not the scientific man. Assuming this to be so, it is perfectly clear that the advancement of the chemist in England has been retarded by a lack of public appreciation of the service which he renders or can render to the nation. What, then, is the chemist in England going to do about it? Apparently he is dissatisfied, which in itself is all right, but being dissatisfied does not alone change inexorable facts. In every chemical problem that confronts the chemist when facts stand in his way he does not get excited about them, but seeks to surmount them by careful study and the devising of ways and means. This should be the attitude of the chemist in England, and by organized publicity—advertising if you will—he should seek to change public opinion so that it will accord to him a higher recognition.

That the English chemist is taking this view is indicated by a recent address by G. G. Henderson before the Chemical Section of the British Association for the Advancement of Science, Newcastle-on-Tyne, 1916. In discussing the synthetic production of nitric acid from the air and the great advantage it would be to England, he laments that England has done nothing in the matter except to appoint a committee to consider possibilities. Then he goes on to say: "This case is only too typical of many others. A number of different causes have contributed to bring about this state of affairs, and the responsibility for it is assigned by some to the government, by others to the chemical manufacturers, and by still others to the professors of chemistry. I think, however, it will be generally admitted that the root of the matter is to be found in the general ignorance of and indifference to the methods and results of scientific work which characterize the people of this country." He adds, however, that he thinks that the English leaders in science have done all that lay in their power to awaken the country to the inevitable and deplorable results of this form of "sleeping sickness," and that he believes that a brighter day is dawning, and that if they rise to the occasion now, chemistry in that country will attain the position of importance which is its due.

Let us take another case. Germany has made great advances in chemistry. Some think that this is due to her system of education, and probably this is partly true. Some think that it is due to the far-sighted wisdom of public men. This, too, is probably partly true, but the real success of chemistry in Germany in my own opinion has been due to its greater popular appreciation. Historians have long since dropped the idea that kings and rulers in general amount to very much in the progress of a nation, and have adopted the broader conception that progress ultimately is in the people of a nation, their developing thoughts, their appreciation of the world that is about them.

The lesson to us in the United States is this—that if we wish chemistry to become a more potent factor in the industrial growth of our country we must take such steps as are necessary to bring about a popular appreciation of its value. Universities will help, government aid will help, but these too depend upon popular appreciation both in their beginning and in their execution; after all, they are mere incidents to fundamental active causes. Create a demand for universities and universities will rise, as it were, over night; create a demand for governmental interest and governmental interest will come quickly and effectively, but demand is born of popular appreciation.

Mr. Elwood Hendrick in an article that appeared not

very long ago in one of our popular journals emphasized this point in urging the popularization of chemistry, and he expressed the thought that chemists would not come into what they believed to be their own until this was done. Mr. Hendrick's suggestion would indicate the advantage of chemists generally advertising their profession, not necessarily, however, in the form of paid advertisements, but in properly written articles for the popular press. The desirability of such a procedure properly carried out is fairly obvious, subject to some limitations, which we will consider further on.

As an illustration of what we can accomplish in this direction I would refer to Robert Kennedy Duncan's writings (particularly his "Chemistry of Commerce") as having been exceedingly efficient in popularizing chemical knowledge, and to the fact that Duncan's efforts in this direction probably resulted in the establishment of the Mellon Institute. As another example of a very commendable effort to popularize chemistry, I would refer to the Chemical Expositions, the second of which was held last September in the city of New York. When the first exposition was proposed, many chemists expressed a great deal of doubt as to its wisdom and practicability, but as the time approached for the opening of the exposition its value to chemists became more clearly recognized and it received from them a very generous and hearty support. So successful was the first exposition that immediately a second one was projected. This received even more generous support, and two of our largest chemical societies decided to hold meetings at the same time. The public press has been full of matter descriptive of the exposition itself and the accomplishments of chemistry thereby illustrated, and gave much space to the papers and discussions, presented at the meetings of the two chemical societies. These expositions were distinctly advertising in their character and great expenditures with the expectation of profitable return were made by the exhibitors themselves.

Our National Departments of Agriculture and Commerce have done much in popularizing chemistry. The work of Dr. Wiley started in the Department of Agriculture has extended the knowledge of chemistry in popular fields through the publication of numerous bulletins and leaflets. More recently the Department of Commerce has, through special investigators, been instrumental in increasing the knowledge of the relation of chemistry to industry. Similar work has been done to some extent by the Department of the Interior.

It seems hardly necessary that I should go further in emphasizing positive aspects of this phase of my subject. Let us consider now some of the criticisms that have been offered on work of this kind. The most general criticism is that when an attempt is made to popularize a science such as chemistry many unscientific statements will be made and true representations will often be incorrectly interpreted by the public. This is undoubtedly so. Erroneous ideas have been promulgated in this way, but the chance to err is not confined to popular presentations. We know that many errors have crept into scientific literature, necessitating laborious effort later on for their correction. To err is human, and the danger that error may occur should not act as a preventive of public statements, whether these are made in the scientific or popular press.

Another objection comes from those who hold that the profession of chemistry is of a very exalted character and that the serious chemist will not descend to ordinary popularizing effort. Our own code of ethics would prevent the chemist from advertising in a sensational manner, and requires the professional chemist to publish scientific papers in the technical journals

before they are given to the popular press. It seems to me that our code of ethics is correct in this respect. We do not want to advocate sensationalism and we do want to build up our technical journals, but after the requirements of our code have been complied with there still seems to be a field open to the chemist in which he can with perfect propriety popularize his science.

The advocates of the study of pure chemistry are also apt to look down upon this popularizing scheme. To them popular science is offensive, and it may be that some of them can hardly be expected to sympathize with the views I am here presenting. The student of pure science is, however, almost in a class by himself. The utmost that he does in affecting the world's processes is by furnishing information, studies and generalizations to be applied by the practical chemist in furthering the interests of the entire world. Far be it from me to depreciate the value of the pure scientist. We all draw upon him for help in our practical efforts. It must be admitted, however, that he lies essentially outside of the plan that we are proposing. He indulges more or less in an esoteric culture and his light, though it is not hidden, is reflected to the world at large only by those who can practically direct that light to the illumination of ordinary things. In spite, therefore, of all that may be said against the popularization of chemistry, I am still convinced of the wisdom of such a purpose, because it is only by so doing that even the student of pure chemistry will be given an opportunity to carry on his studies. So firm is my belief in this that I would extend this effort so that it would reach and include the most humble members of society.

In order to present in picture form, as it were, the dependence of the chemist for his success upon the popular appreciation of chemistry, let me present the following sketch: A chemist makes what he believes is a discovery of great financial value. If he has money enough of his own he may be able to make that discovery a source of financial profit, but in so doing he will have to be something in addition to a chemist, for the largest part of his effort will be along lines which are essentially non-chemical, involving the organization of business, the advertising of the product or process, and its sale for use. In proportion as the public is capable of appreciating what he has accomplished, to just that extent will he make a financial success. Suppose, on the other hand, this chemist is not a man of means and wants to interest financial people in his discovery. As things are to-day he will first encounter skepticism, even ridicule, and if finally he is successful in having his discovery appreciated by financial interests, it will be because he has been able to convince them of its human aspects, and it may be that before he is through a great part of the value which he has seen in his discovery will have been absorbed by what the financial interests think is their proper return. The ordinary business man of to-day very naturally thinks that his business ability is more valuable than the technical ability of the chemist. He wants the lion's share. There is no use in closing our eyes to this fact. Many a poor inventor or discoverer has been so discouraged in his early efforts for recognition that he has been almost ready to drop his entire proposition. He says the blame lies on an unappreciating public, and this is true, but if it is true, how incumbent it is upon the chemist to make the public appreciative. He can do this only by studying the public, finding wherein the public should be educated, and recognizing all its limitations, work with wisdom toward the accomplishment of his purpose.

(To be concluded.)

New York Meeting of American Institute of Chemical Engineers

The winter meeting of the American Institute of Chemical Engineers was opened on Wednesday, Jan. 10, in Rumford Hall, Chemists' Club, New York City, with a business meeting at 10 a. m. In the absence of the president, Dr. Rosengarten of Philadelphia, Vice-President GUSTAV W. THOMPSON, chief chemist of the National Lead Company, presided. And rightly so, for when the committee for canvassing the letter ballots for the annual election of officers (Mr. A. E. Marshall, chairman) presented its report in the evening session, Dr. G. W. Thompson was declared the new president of the Institute by unanimous vote.

The business session in the morning was devoted to the presentation of a long series of reports by the chairmen of the standing committees or in their absence by Secretary Olsen. The monotony of the presentations of committee reports was relieved by a liberal sprinkling of discussions on various angles of professional ethics. Though the Committee on Ethics had not any report of its own, there was more talk—and interesting talk—on ethics during the morning session than we have listened to for a long time.

After the close of the business meeting three papers were presented.

First, an address by the retiring president, Dr. GEORGE D. ROSENGARTEN on chemical preparedness was read by Dr. Olsen in the author's absence. It discussed the peculiar conditions of industrial unpreparedness in which this country was found after the start of the European war.

The paper was referred to the Committee on Public Relations after some discussion in which Messrs. Andrews, McKenna and Withrow participated.

Mr. H. D. MILES, president of the Buffalo Foundry & Machine Company, followed with an interesting review of recent developments in chemical engineering equipment by his company. The Buffalo Foundry & Machine Company was founded sixteen years ago on what was then a radically new basis, namely as a modern foundry on a scientific laboratory-controlled basis. Chemical castings soon became its principal products and the company soon succeeded in turning out caustic pots which had a longer life than European-made pots. Attention was then turned to the manufacture of chemical retorts, acid eggs and acid kettles, as well as vacuum dryers, pumps, and condensers.

Mr. Miles described in some detail the principles of his company's vacuum drum dryer. One of its most extensive uses has been the production of powdered chestnut and hemlock extracts, another the recovery of dry sulphite waste from the waste liquors of paper mills.

When the European war broke out, there was a sudden and large demand for chemical equipment and the Buffalo Foundry & Machine Company entered into the manufacture of equipment for various chemical industries new to this country. Mr. Miles described improvements in machinery for synthetic phenol and the use of the atmospheric drum dryer and sketched advances made in the design of a reducer for the manufacture of aniline oil and of apparatus for the distillation of beta naphthol, the construction of antoclaves for the production of dimethylaniline, the design of new denitrating apparatus for the distillation of nitric acid from a mixture of nitric, sulphuric and water. Mr. Miles finally referred to the manufacture of acid-resisting castings and mentioned the erection of a large research laboratory as the latest undertaking of his company.

A paper by Professor HERBERT T. KALMUS and K. B. BLAKE was then read by title, as printed advance copies of this paper were available. (Several of the papers were printed in advance—a novelty with this Institute and a highly commendable one.) The paper gave the results of a series of investigations extending over a period of several years of the effects on the corrosive properties produced by the addition of various amounts of cobalt, nickel, or copper to a very pure commercial iron. The investigations were made at Queens College, Kingston, Ontario. The results show in general that cobalt, nickel and copper increase the resistance to corrosion. The authors consider the phenomena of corrosion more complex than has been generally stated by the electrolytic theory.

From the authors' summary of results we quote the following:

The corrosion, or loss of weight in grams per square centimeter of original surface per hour, is the function of the length of exposure, being less for the longer exposures. This is true because of the property of these alloys to form a self-protecting layer or coating.

The alloys formed by the addition of small percentages of copper, nickel and cobalt (from 0.25 per cent to 3.0 per cent) to pure iron, are more resistant to atmospheric corrosion than the pure iron, from which the alloys were prepared.

Considering the data for alloys formed by adding various amounts of cobalt (from 0.25 per cent to 3.0 per cent) to pure iron, with very little, if any, carbon content, it is apparent that the corrosion is not a simple function of the percentage of cobalt content. In general, the corrosion of the alloys formed by the addition of 3 per cent of cobalt to pure iron is about 75 per cent as great as that of the alloys formed by the addition of 0.5 per cent of cobalt.

Alloys formed by the addition of 0.25 per cent to 3.0 per cent cobalt to pure iron, with very little, if any, carbon content, are corroded in the atmosphere to an extent varying between 50 per cent and 75 per cent of that of the pure iron from which the alloys were prepared.

These two last conclusions are approximately true for the corresponding nickel alloys as for the cobalt alloys. There seems to be very little choice between the use of nickel and cobalt to form alloys with pure iron containing between 0.25 per cent and 3.0 per cent of the added metal for the prevention of corrosion.

As corrosion progresses, all of the alloys prepared form self-protective coatings of oxides. It is noticeable throughout that the oxides formed by the cobalt are darker, denser, and more tenacious than those formed by the other alloys.

The effect of preventing corrosion of the protective coating just mentioned does not seem to have worked greatly to the advantage of cobalt alloys, in spite of its more satisfactory appearance, in the length of time that the above experiments were allowed to run.

In order to finally conclude the possible ultimate advantages of the cobalt alloy protective coating, as compared with the other sheets, all of the alloys should be allowed to corrode to destruction. The results of such tests, as are being made by the authors, will be published later.

The addition of copper to pure iron to an extent between 0.25 per cent and 0.75 per cent seems to be conducive to reducing the corrosion of the iron under atmospheric conditions. It is difficult to say whether or not the addition of copper in these amounts has a greater or lesser effect than the corresponding amounts of nickel or cobalt. Additional experiments will be required to determine these facts, but there can be but

little doubt that the addition of copper, as above reported, diminishes the corrosion of the pure iron.

The amount of corrosion varies with the percentage of carbon in the alloy, as would be expected.

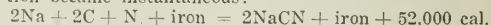
The paper was discussed in the evening session at great length by Dr. A. S. Cushman of Washington, who after giving a sketch of the history of American ingot iron considered that the authors' tests were inconclusive. He insisted that no conclusions can fairly be drawn from tests with such small samples. Only exposure tests with large full-size sheets give fair results. He has himself such tests going on. The use of nickel and cobalt he considered prohibitive on account of the price. He does not think that the authors' conclusion as to the effect of copper is justified. He considers standardization of quality and material (American ingot iron) to be all important.

Professor JOHN F. BUCHER, of Brown University, Providence, R. I., followed with a paper on the fixation of atmospheric nitrogen. Professor Bucher spoke extemporaneously for over two hours in a most interesting manner. As this was the first public statement of his researches (outside of several patents which were abstracted in our Vol. XII, p. 725, and Vol. XIV, p. 543) he was listened to with great attention. Two points stand out strongly. First, Professor Bucher fixes the nitrogen in form of cyanide. Second, his process does not require a large amount of power and therefore does not presuppose the availability of cheap waterpowers. It can be carried out at any place where sodium carbonate, iron and carbon are available and can be easily carried on in an emergency.

Professor Bucher reviewed former attempts to fix nitrogen as cyanide, all of which were failures, but pointed out that as early as 1837 iron was claimed to be favorable. Professor Bucher indeed found that finely divided iron as a catalytic agent is necessary. His first experiments were made in a tube furnace with the reaction

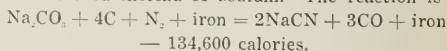


There is some reaction, but very little. But as soon as finely divided iron is added to the graphite, the reaction became instantaneous:



This is a fine method for getting argon for lecture experiments. The reaction is interesting in another way. If not enough carbon is provided in the mixture, the sodium vapor will absorb carbon from the iron and decarbonize it.

In the present process of the author's sodium carbonate is used instead of sodium. The reaction is



It is an endothermic reaction. The nitrogen need not be pure by any means. Producer gas works as well as nitrogen, neither better nor worse. Finely divided hematite is as good a catalyzer as finely divided iron and much cheaper. The mixture is briquetted simply with water, without any tar or pitch admixtures.

The author then turned to a sketch of the engineering development of the process. Very simple apparatus is required. A vertical tube furnace heated electrically was described (see our Vol. XIV, p. 543). Professor Bucher touched in his further remarks on a great many other researches into which he was led by the development of this process.

After the close of the session there was an enjoyable smoker tendered by the Chemists' Club.

A fuller report of the papers as well as a report of the proceedings at the Friday sessions must be reserved for our next issue.

An Investigation of the Brittleness Produced in Steel Springs by Electroplating

By M. DeKay Thompson and C. N. Richardson

The fact was called to our attention several years ago by Dr. W. H. Whitney that small steel springs become brittle when plated in copper cyanide baths. The object of the following work was to find the cause of this deterioration and under what conditions it does and does not occur.

The steel wire used in these experiments were several sizes of Edgar T. Ward & Sons' "black tempered spring wire" and piano wire.

The first experiments were to determine whether steel springs are injured by plating in a nickel bath containing no cyanide. The bath had the following composition: Nickel ammonium sulfate, $\text{NiSO}_4(\text{NH}_4)_2\text{SO}_4\cdot\text{H}_2\text{O}$, 70 grams; ammonium sulfate $(\text{NH}_4)_2\text{SO}_4$, 10 grams; water, 1 liter.

The pickling solution was 150 cubic centimeters of concentrated sulfuric acid in 750 of water. Short springs were made of black tempered spring wire of the following diameters in millimeters: 1.05, 1.33, 1.65. They were plated at room temperature from one to two hours with a current of from 0.2 to 0.35 amperes. Piano wire of diameters in millimeters 0.28 and 0.33 were plated until their diameters were increased to 0.45 and 0.50 millimeters respectively. The springs were apparently unaffected in any way.

A copper cyanide bath was then made up as follows: Cuprous cyanide, 35 grams; sodium cyanide, 1140 grams; water, 750 cubic centimeters.

A piano wire of 0.46 millimeter diameter was then made into a spring and was plated in this solution with 0.45 ampere. The spring was under a slight tension during the plating and broke at the end of twenty-two minutes. No copper was deposited, the current density being too low. A spring made from black tempered spring wire 1.05 millimeters in diameter was plated with 6.15 amperes and a good deposit of copper was produced. After twenty minutes the spring was removed and was easily broken by stretching.

Larger sizes of the steel and wire of other metals were not affected by plating in this solution, as shown by the following data:

Material	Diameter	Duration of Plating Minutes	Amperes
Steel	1.57	25	10
Steel	2.02	25	10
Steel	2.54	25	15
Brass	0.53	21	10
Brass	1.03	30	10
Phosphor-Bronze	0.64	27	10

None of these wires broke.

In the first experiment in cyanide solution only hydrogen and no deposit of copper was produced, and the spring became brittle. As hydrogen is known to make electrolytically deposited iron very brittle, this suggested that the hydrogen liberated might have penetrated the steel and have caused its brittleness. In order to test this steel springs were electrolyzed as cathodes in a 15.5 per cent sodium hydroxide solution as follows:

Diameter in millimeters	Duration minutes	Amperes
0.33	35	1.50
0.46	49	5.00

They were entirely unaffected, showing that hydrogen is not the cause of the trouble.

A solution of sodium cyanide containing originally no copper was next tried. As a copper anode was used to prevent the escape of cyanogen, a small amount of

copper went into solution during the electrolysis. The results with steel wire were as follows:

Diameter in millimeters	Duration minutes	Amperes
0.29	38	1.5
0.46	9	7.0
1.01	60	14.0

Only the wire 0.46 millimeter in diameter broke. The conditions of the experiment did not remain constant on account of the solution of copper at the anode, causing deposition at the cathode.

A platinum anode was then used, and the cyanogen was passed into a solution of sodium hydrate for absorption. The electrolyzing vessel was a wide mouthed Erlenmeyer flask.

Springs made of 0.46-millimeter wire were electrolyzed for ten minutes with 7 amperes, one in sodium cyanide alone and the other in sodium cuprocyanide. Both were brittle, but the one electrolyzed in sodium cyanide was much more so than the one in sodium cuprocyanide.

It was also found that the wire was most brittle nearest the point of support, and that the brittleness decreased with the distance from this point. This must be due to the greater current density near the support where electrical contact is made.

It was found that the same brittleness is produced in straight wire which has not been bent or coiled. No effect is produced by mere contact with the solution. A spring made of 0.46-millimeter wire was suspended under tension for two hours in a sodium cyanide bath with no current passing. It did not become brittle.

These experiments indicate that the cyanide radical in combination with electrolysis is the cause of the brittleness. The fact that the brittleness is more pronounced in the absence of copper is probably due to the protection the steel gets from the layer of copper deposited. This suggested that the brittleness might be due to a kind of case-hardening by the cyanide radical. These experiments were all at less than 100 deg. C., and such an effect at this temperature seemed very improbable. It was, nevertheless, tested by analyzing the wire for carbon before and after it had been made brittle. The chromic acid method was used (Treadwell-Hall, 1914 edition, page 391). The following results were obtained:

Per Cent Carbon Before Electrolysis	After Electrolysis
0.70	0.73
0.78	0.65
Av. 0.74	0.69

As these check within the limits of the accuracy of the analysis, this suggested case-hardening effect does not take place. This wire was 0.46 millimeter in diameter and was electrolyzed at 80 to 85 deg. C. with 3.5 amperes for one hour and fifteen minutes. The electrolyzed wire was brittle.

There seemed nothing left to explain the brittleness except a possible change in the crystalline structure of the steel. This was therefore examined next.¹

In order to get a polished cross-sectional surface, several pieces of wire were clamped between brass strips, with the ends projecting a little beyond the brass. These were then ground down flush with the brass, and the whole surface, brass and steel, was polished with rouge. The surfaces were etched with a 4 per cent solution of nitric acid in alcohol. The structure of the steel before and after electrolysis did not show any differences.

As all wire is drawn cold and has internal strains, it was next decided to see whether the brittleness is

¹We wish to express our thanks to Professor Henry Fay for his kind assistance in this work.

still produced after internal strains have been removed. In order to remove the strains, some steel spring wire 0.40 millimeter in diameter was heated in an electric furnace as follows:

Time	" C.
11.25	740
11.45	760
12.45	500
12.45	356
1	Room temp.

700 deg. C. is the transition-temperature of 0.7 per cent carbon steel. This wire was then electrolyzed for 1.5 hours with 3 amperes at 80-85 deg. C., without producing brittleness. No difference in the structure was found. Electrolysis of wire as cathode therefore does not produce a change in the structure.

Electrolysis of the wire as anode was next tried. A spring of steel wire of 0.46 millimeter diameter was electrolyzed as anode for fifty minutes with 3.5 amperes at 80-85 deg. C. It was not made brittle.

The surface of the brittle springs and the fractures of the brittle wire were then examined with a microscope for a possible explanation. The surface of the wire showed shallow scratches parallel with the axis of the wire, doubtless caused by the die. The crystal structure could also be distinguished. The majority of the fractures of the brittle wire seemed to follow these scratches, but no further connection between brittleness and scratches was found.

As no other possible explanation of brittleness produced by electrolysis could be thought of, these experiments were for the time at least reluctantly discontinued.

SUMMARY

Though the explanation of the brittleness produced in a spring wire when used as a cathode in a hot cyanide solution could not be found, the following results were obtained:

1. Spring steel becomes brittle when used as cathode in a hot cyanide solution, either sodium cuprocyanide or simply sodium cyanide. The effect is more pronounced with the simple salt. Brass and phosphor-bronze are not affected.
2. Brittleness was not produced by the liberation of hydrogen on the steel.
3. The carbon content is not changed by the electrolysis.
4. The crystalline structure is not changed by electrolysis.
5. The brittleness is not produced in annealed wire.
6. The brittleness is produced by use as cathode whether the wire is coiled or not bent in any way.
7. The brittleness is not produced when the wire is used as anode, or when it is suspended in the solution without the passage of electricity.

Massachusetts Institute of Technology.
Cambridge, Mass.

The Minerals Separation North American Corporation has been organized under the laws of Maryland with 500,000 shares, having no par value, by the Minerals Separation Co., Ltd., of England, to handle the latter's business in North America. The new company will take over all the assets and business of the Minerals Separation American Syndicate which was formed in 1913 and in which Americans have an interest.

Meeting of the Teknik Club at Denver. On Dec. 12, 1916, the Teknik Club held its monthly meeting. Two papers were presented, one by Mr. Proffitt, entitled "The Use of the Polariscope in the Sugar Industry," and a second one by Mr. J. A. Hunter, "The Work of the State Bureau for the Inspection of Oils."

Analysis of Babbitt Metal; Alloys of Tin, Antimony, Lead and Copper

By E. W. Hagmaier

PREPARATION OF THE SAMPLE

Break or saw the ingots squarely across and file after removing the roughness. If care is taken an accurate sample of the cross-section can be taken. A sample may also be taken by sawing through the ingot several times and collecting the sawings. These sawings or filings should be gone over with a magnet to remove any iron which might contaminate the sample.

ANTIMONY

One gram of the filings is dissolved in an Erlenmeyer flask (800 c.c.) with 10 c.c. of water and 25 c.c. of sulphuric acid. When solution is complete and no black shows in the bottom of the flask remove from the hot plate and cool. Now add 100 c.c. of water and 10 c.c. of hydrochloric acid and boil 10 min. to expel sulphurous fumes. Cool, and add 100 c.c. of water and titrate with potassium permanganate.

TIN

Dissolve a half-gram sample in 30 c.c. of hydrochloric acid in an 800-c.c. Erlenmeyer flask, using gentle heat, and if it is impossible to get complete solution add a small amount of potassium chlorate, but add this sparingly in order not to weaken the acid too much. When solution is complete add 150 c.c. of water and 80 c.c. of hydrochloric acid. Place a strip of ingot iron in the flask and cover with an inverted crucible cover and boil for an hour, or until all the tin is reduced. Remove the flask from the plate and cool quickly; when cool remove the strip of ingot iron and titrate at once with 0.1 normal iodine solution.

LEAD

Place a convenient sample in a 250-c.c. beaker and add 5 to 15 grams of tartaric acid. The amount of this acid depends on the amount of tin in the sample, more tin requiring more of the tartaric acid. To this mixture of acid and sample add 15 c.c. of boiling water and 3 c.c. of nitric acid. When solution is complete add 3 c.c. of sulphuric acid and boil until all brown fumes cease to come off and then give about 1 min. more and remove from the plate.

Care must be taken not to boil too long after the fumes cease to come off, as the sulphuric acid will char the tartaric acid. When all fumes are off cool the solution and add 50 c.c. of water and filter off the lead sulphate, washing the precipitate with 2 per cent sulphuric acid solution. Dissolve the sulphate in hot saturated ammonium acetate solution, add 2 c.c. of acetic acid, bring the solution to a boil and add potassium chromate; boil the contents until the lead chromate settles well. Filter on a tared paper, washing well with hot water, dry at 100 deg. C. and weigh and calculate to lead.

COPPER

To determine the amount of copper treat a larger sample in the same manner as that for tin to the point where the lead sulphate is filtered off; when the lead is filtered off and the precipitate is washed so that no copper remains held in the precipitate, then discard the precipitate and add 2 or 3 c.c. of hydrochloric acid to the filtrate and several pieces of copper-free aluminium and place on the back of the plate and the copper will be thrown out of solution.

When all the copper is thrown out filter off, wash several times with hot water and redissolve the copper

in dilute nitric acid, washing the paper free from all traces of copper and determine the copper by titration or by electrolytic deposition.

COPPER TITRATION

Weigh out $\frac{1}{2}$ gram of copper foil and dissolve in 5 c.c. of nitric acid; when all dissolved and all brown fumes are driven off neutralize with sodium carbonate and then make acid with (1-3) acetic acid and cool. To the cold solution add 3 grams of potassium iodide and stir until this is all dissolved. The solution will be a brown with a white precipitate.

Titrate at once with 0.1 normal thiosulphate solution with continual stirring. As the thiosulphate is run in the brown color will fade; when it is pale add 10 c.c. of a starch solution and continue to titrate until the blue color is gone entirely.

PRECAUTIONS

Keep concentrated, have slight excess of acetic acid, have completely cold before adding the iodide, add sufficient iodide, and stir continually during titration.

Buffalo, N. Y.

Vaporization of Metallic Copper in Wirebar Furnaces

By Allison Butts

The question of the vaporization of copper, silver, gold and other metals in refining furnaces is of considerable importance. It has been known for a long time that there is a loss due to this cause—similar to the evaporation of water from an open vessel at ordinary temperatures—but little has been known either of the extent of the loss or of the circumstances attending it. Some recent experiments give us more knowledge on this subject and afford the basis for some interesting theory. The latter is perhaps at present not of much practical value, but this may develop later in the light of more knowledge and experience.

The present consideration of loss by vaporization was first made in connection with refining of electrolytic copper slimes, when some experiments were made to determine the stack loss. It was found that the bulk of the loss was due to fine particles of slimes carried through the scrubber and out of the stack by the draft. However, the material which passed out of the stack during the later stages of the Doré refining process, when air was being blown into the molten bath, while less in amount was richer in gold and silver, and had the appearance of being mixed with condensed fume. This indicated that part of the loss was due to vaporization.

Any theory with regard to loss by vaporization in the silver refinery was complicated by the fact that a number of different furnaces discharged their gases into the same flue system, by the presence of the scrubber, and by the large amount of metals present as impurities, at least one of which, selenium, forms a comparatively volatile compound with silver. But in the case of other experiments made on wirebar furnaces, there was but one source of metallic vapor to consider, namely, a very pure copper bath.

Copper at the temperature of the melting furnace has an appreciable vapor pressure, and as a result a certain amount of copper vapor from the bath will become mixed with the hot gases and be carried with them into the flue. This amount will be a maximum at the "saturation point" for copper vapor, the limit depending on the temperature in the furnace. Let us first calculate this maximum amount, taking the total pressure at 760 mm., from which it will not vary by more than a

few millimeters, and the temperature at 1120 deg. C., a fair average temperature for the refining process.¹

The vapor tension of copper at 1120 deg. C. is about 0.28 mm. The partial pressure of the copper vapor in the furnace is therefore $\frac{0.28}{760} = 0.00037$. This is equivalent to saying that 0.037 per cent of the total volume of furnace gas is copper vapor.

Measurements of the total volume of gas passing through the furnace and up the stack during the running of one complete charge (time about twenty hours, taken from the time when the charge begins to melt to the end of casting) showed an average of 440,000 cu. m. (15,700,000 cu. ft.) at standard conditions, 0 deg. C. and 760 mm.; 0.037 per cent of 440,000 = 163 cu. m., the volume of copper vapor passing out of the furnace. One cubic meter of copper vapor at standard conditions weighs $0.090 \times \frac{63.6}{2} = 2.86$ kg.; $163 \times 2.86 = 466$ kg. (1025 lb.) of copper per charge.

Now compare this maximum possible loss with the actual loss found by experiment. The furnaces tested were 200-ton reverberatories equipped with waste-heat boilers and economizers. The dust which settles out in the waste heat apparatus and connecting flues was removed usually once a month, and the amount of copper thus recovered averaged over a period of ten months 20 kg. (44 lb.) for each charge of cathodes melted. In addition the bricks and mortar on the inside of the boiler setting become impregnated with flue dust and copper and a certain amount of slag is formed. The boiler slag was recovered from time to time and, together with the coating on the brickwork, accounted for an average of 20.5 kg. (45 lb.) of copper for each charge. The stack loss experiments showed an average of 39.1 kg. (86 lb.) of copper lost from the stack in unrecovered flue dust. Thus there is indicated a total of 79.6 kg. (175 lb.) of copper passing out of the furnace into the flue apparatus each charge.

It seems probable that nearly all of this loss is due to vaporization, since a charge of clean cathodes and remelted refined castings obviously offers little chance for other fume losses, and particles of metallic copper would for the most part be too heavy to be carried by the draft. During poling there is considerable splashing with the formation of minute particles of copper, sometimes called "copper rain," and it is probable that some of this is carried into the first boiler chamber. This question is considered further in connection with the form of the copper in the flue dust. If it is assumed for illustration that all of the 79.6 kg. is vaporized, it means that the percentage saturation of the furnace gases with copper vapor is $\frac{79.6}{466} \times 100 = 17.1$ per cent, an entirely reasonable figure.

The stack loss referred to above was determined by the usual experimental baghouse method. The temperature of filtration of the gas was about 150 deg. C. The vapor tension of copper is not known at this low temperature, but a theoretical value can be obtained by extending the vapor tension curve beyond the known limits. In this way it can be shown that the amount of copper vapor uncondensed at 150 deg. C., and therefore passing through the bags, would be a fraction of a gram.

Suppose the gases leave the furnace at 1120 deg. C. and 17 per cent saturated with copper vapor. They cool immediately to a temperature at which they are 100 per cent saturated by the amount of copper vapor pres-

¹For data on metallic vapor tensions and methods of calculation, see Richards' "Metallurgical Calculations," Vol. 3, pp. 588-593.

ent, and the copper accordingly begins to condense. This temperature can readily be found. At 1120 deg. 466 kg. are necessary for saturation, producing a partial pressure of $\frac{0.28}{760}$. The partial pressure of 79.6 kg.

would be $\frac{79.6}{466} \times \frac{0.28}{760} = \frac{0.048}{760}$, and the vapor tension of the copper vapor would therefore be 0.048 mm. Reference to the curve shows that this tension corresponds to a saturation temperature of 1005 deg. C., or 79 deg. below the melting point of copper.

The furnace gases passed first through the waste-heat boiler, then the economizer, and then up the stack. Typical assays of the dust recovered in each of these places are as follows:

	Boiler dust.	Economizer dust.	Stack dust.
Au. Oz. per ton.....	0.03	0.02	0.02
Ag. Oz. per ton.....	3.00	2.20	1.60
Cu. per cent.....	23.51	18.62	15.03
S. per cent.....	9.41	9.00	7.31
Fe. per cent.....	5.55	7.21	4.47
CuO. per cent.....	1.26	1.27	...
Ins. per cent.....	23.37	25.69	...
SiO ₂ per cent.....	...	...	18.33
As. per cent.....	...	...	0.37
Pb. per cent.....	...	...	0.20
Zn. per cent.....	...	...	Tr.

Other constituents were not determined.

Samples of the three kinds of dust were leached with boiling water. It was found that of the copper in the boiler dust about 60 per cent was soluble, in the economizer dust about 85 per cent, and in the stack dust about 90 per cent. These tests, together with the percentages

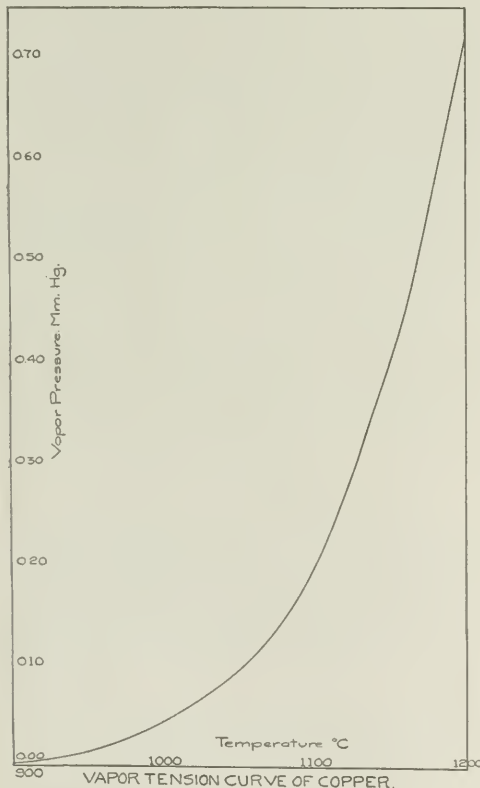


FIG. 1—VAPOR TENSION OF COPPER AS FUNCTION OF TEMPERATURE

of sulphur, made it apparent that the copper was largely present as copper sulphate. The vaporized copper must accordingly become oxidized and combine with SO₂, either before, during or after condensation. Anhydrous copper sulphate breaks up into CuO and SO₃ at 670 deg. C., so that any copper which condensed above this temperature could not combine with SO₂, at least until after condensation. The cooling below this temperature, of course, takes place very quickly in the boiler chamber. The gases enter the chamber at a temperature of about 950 deg. C., leave it at 400 deg. C., and leave the economizer at 300 deg. C. It will be noted in the above analyses that the boiler dust has the highest percentage of copper and the lowest amount soluble. This may be taken as an indication of the copper condensed above 670 deg., but it is also to be remembered that some unvaporized particles of copper may be borne into the boiler chamber, especially during piling. More information could be obtained on this point by taking samples of dust at different points in the chamber.

CONCLUSIONS

1. 440,000 cu. m. (15,700,000 cu. ft.) of gas (at standard conditions) pass through one of the 200-ton wirebar furnaces during the treatment of one charge after melting begins, and if saturated would contain 466 kg. (1025 lb.) of copper vapor.
2. 79.6 kg. (175 lb.) of copper actually passes from the furnace, probably due mostly to vaporization.
3. Of this, 39.1 kg. (86 lb.) is lost from the stack, 20.0 kg. (44 lb.) is recovered in dust from the waste-heat installation, and 20.5 kg. (45 lb.) is recovered in boiler slag and clobber.
4. The furnace gases at 1120 deg. C. are nearly 17 per cent saturated with copper vapor.
5. The copper vapor begins to condense at 1005 deg. C., which is about 55 deg. above the temperature at the entrance to the waste-heat boiler.
6. The copper is contained in the dusts largely as copper sulphate. The boiler dust averages about 23 per cent copper, the economizer dust 18 per cent, and the stack dust 15 per cent.
7. The copper in the boiler dust is about 60 per cent water soluble, in the economizer dust 85 per cent, and in the stack dust 90 per cent.

It should be borne in mind that figures on metallic vapor tensions are inexact, being for the most part drawn by inference from the known vapor tensions of mercury and supported by isolated data. Most of the figures given in this article are therefore to be regarded only as approximate. In checking the points on the vapor tension curve, the writer was able to make use of a valuable law of vapor tensions which will be published later by Dr. J. W. Richards, whereby the entire vapor tension curve of a substance may be plotted when a single point is known, *e.g.*, the boiling point of the substance. In determining the graph for copper, the normal boiling point of the metal was taken as 2100 deg. C.

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Meeting of the Utah Section of the American Institute of Mining Engineers. On Dec. 16, 1916, the meeting of the Utah section of the institute was held at the Hotel Utah. The meeting was opened by an informal dinner. Then followed the election of officers for the coming year. After the election, J. M. Callow presented a paper, "Notes on Flotation, 1914." The second paper presented was by Erwin Wilke, entitled "The Manufacture and Use of Sulphuric Acid." A splendid musical program and entertainment helped to make the meeting of more than ordinary interest.

The Calculation of Lead Blast Furnace Charges for Students of Metallurgy

By Boyd Dudley, Jr.

Perhaps there is no better way for the student of metallurgy to become familiar with the chemical and metallurgical principles involved in a smelting process than for him to learn something of the calculation of furnace charges to be employed in conducting the operation in question. Authorities may differ on this point, but certain it is that an understanding of methods of charge calculation is an invaluable aid to the student in his critical study of any smelting process, even though it does not provide him with all of the information he should possess. Furthermore, it is the experience of the writer that charge calculation problems may be undertaken in connection with the ordinary lecture-room metallurgical course with excellent results, on account of the natural appeal that they seem to make to most students. It appears that the student recognizes, without the necessity of having it pointed out to him, that in the solution of these problems there is contained much of the essential information that he should have. Consequently, he approaches the subject with a certain degree of enthusiasm that, unfortunately, is sometimes lacking from his attitude toward other problems.

It is thought that an outline of methods for calculating lead blast furnace charges that have proven useful in class-room work will be of interest to students and teachers—perhaps to others—and it is with this idea that the present paper is presented. That there is nothing new or revolutionary in the methods to be described goes without saying. They are old and have seen long service. But they differ somewhat from those outlined in most metallurgical textbooks, and the presentation of them will therefore serve a useful purpose.

In the first place it may be well to state that a charge calculation generally consists of so determining by computation the amounts of various materials that are to be smelted that these will be present in the proportions necessary to produce, when the charge is actually smelted, a slag of the desired composition. Aside from slag composition there are other considerations to be taken into account in most charge calculations. But these are generally subsidiary to the one first mentioned, and for that reason do not have to be enumerated in detail in the definition.

METHODS OF CHARGE CALCULATION

The ordinary methods of charge calculation may be roughly divided into three classes:

1. The slag-forming constituents of each material on the charge are balanced against each other, and the excess of one constituent over the other is determined. Proper combinations of each of the various materials with the others are then made on the basis of these excesses. This is frequently called the available flux method.

2. Algebraic equations involving the amounts and analyses of the various materials and involving all of the conditions of operation are formulated and solved, the amounts of the different materials being thus determined. From the application of this method rigorously precise results may be expected. But the conditions to be observed and taken into account in the blast furnace treatment of lead ores are usually so complex that the solution of a number of simultaneous equations representing them generally proves to be a somewhat troublesome task. At least there are more speedy and equally exact ways of arriving at the desired result.

3. Preliminary estimates or guesses of the amounts of materials to be employed are made. These are en-

tered on the charge sheet, and the weights of the different slag and matte-forming constituents are calculated from the analyses of the materials. It is then determined whether or not these constituents are present in the proportions required to produce the desired slag and to conform to the assumed conditions of operation. If they are not, a second estimate is made and the correctness or incorrectness of the amended charge is determined as before. This process is repeated until the charge is made to balance in a satisfactory manner. This is frequently known as the "cut and try" method of calculation, the name being derived from the nature of the operations employed to effect a solution of the problem.

When employed by one who has had considerable previous experience in the solution of charge calculation problems, the last mentioned method generally proves superior to the two first mentioned in point of speed, and the results can be brought to the desired degree of precision with a minimum of effort. In the hands of the student, however, this method when used alone frequently fails to demonstrate its superiority over the other two. Because the student has not had the necessary previous experience that is needed to develop the ability to judge with some degree of accuracy the amounts of the different materials to be first tried. Hence the first figures that he enters on the charge sheet may be very poorly selected. Then, too, the student is apt to be prejudiced by his previous scientific training against the use of such a method of calculation. It appears to be inexact and unscientific. The result is not secured by a method of strict mathematical analysis, therefore it ought not to be relied upon.

These and other objections arise in the mind of the student and also in the minds of many of his teachers, when the "cut and try" method of charge calculation is proposed. Some of them are just and some are not. That the result is not secured by a process of strict mathematical analysis cannot be denied, but the exactness of the result is quite another matter. The numerical values that are employed in calculations for such quantities as π and $\sqrt{2}$ are not exact, but by employing the necessary number of figures in the decimal they may be brought to such a degree of precision as may be necessary in the calculation being made. So it is with the "cut and try" charge calculation. In fact, when the vagaries of the ordinary furnace in operation are considered, the result can be brought within the necessary limits with very little trouble. As for the unscientific features of the method, they perhaps consist of nothing more serious than the production of the desired result in less time and with less mental and physical effort than it can be secured with the aid of the available flux or algebraic methods, when either of them is used alone.

But if the student is unable to employ the "cut and try" method with marked success on account of his lack of judgment, then why all this argument in favor of it? Because his judgment can be trained or developed, and this without great difficulty. The quantities of various materials that he first enters on his charge sheet need not be wild guesses. By means of available flux calculations he can make reasonably accurate estimates of the amounts of the most important of his materials, and the final adjustment of the charge can then be accomplished by cutting and trying. The amounts to be cut from or added to the preliminary estimates can also be determined according to available flux calculations. Thus he learns to make these estimates by first applying exact available flux computations to his principal materials. As experience is gained and judgment developed the available flux calculations

as a basis of preliminary estimates can be made of a more approximate nature, and the factors judgment and experience are gradually substituted in their place. This is the method or combination of methods that the writer has found very useful in the class-room calculation of lead blast-furnace charges, and it is this that will be illustrated in the following problems.

MATERIALS SMELTED

In burdening the lead furnace the various materials employed may be classed as ores, fluxes, and fuel. There may not in all cases be a sharp line of distinction between ores and fluxes, and since the differences are largely a matter of definition they need not be discussed at length here.

Ores may be of a number of different types, and a single furnace charge may contain a large number of ores and metallurgical products having various characteristics and analyses. Frequently, however, the relative quantities of some of the ores to be smelted will be determined by the amounts or supplies of them that are available rather than by purely technical considerations. In this event, from the composition of the various ores, the relative amounts of which are so predetermined, there may be calculated at once the composition of the composite material that will result from a mixture of them. Thus in many instances even a long charge sheet may be reduced to a comparatively few items—one or two ores or composites, one or two fluxes, and fuel. It may be well to note in this connection that many smelters follow the practice of actually making these mixtures or composites previous to smelting. This is done by spreading the different lots of ore in layers one above the other, thus making ore beds; or by mixing the lots and storing in bins until the time for smelting them arrives.

The fluxes are generally a material that is rich in lime and one that is rich in iron. This is the case when silicious ores are being smelted, because the slags ordinarily produced in lead blast furnace smelting are essentially igneous solutions of silica, ferrous, oxide, and lime, with other constituents in varying but usually smaller amounts. But where ores are being smelted that are rich in lime or iron, then a material rich in silica would be an essential flux. Of the two first mentioned fluxes the former is generally limestone, which may be more or less dolomitic; while the latter may be either a natural iron ore, or in many cases it may be pyrite cinder or other roasted material containing the necessary amount of iron.

The fuel most commonly employed in modern lead smelting is coke. This may be of varying grades depending on the requirements of the individual case, or more often on the supplies available.

BEHAVIOR OF ELEMENTS DURING SMELTING

Before proceeding with the calculation of a charge for any smelting operation it is necessary to make certain assumptions with regard to the behavior of various elements in the charge during the progress of the process. Such assumptions are at best uncertain, and, in the absence of previous experience in smelting the classes of ores under consideration, it is necessary to make them as reasonable as may be and to let the matter rest with that. However, the student should bear in mind that, while he has to make a number of assumptions and solve his problems with these as a base, in a plant where a furnace is to be started many data are generally available that will show the behavior of similar charges on previous occasions. Even such data are not absolutely trustworthy, however, because differences in furnace construction that appear insignifi-

cant will sometimes produce marked differences in operating characteristics; and two furnaces working side by side under apparently the same conditions and on the same charge will frequently produce different results. So the assumptions that have to be made as a preliminary to class-room charge calculations are intended to be reasonable and to supply the student with the data needed in the solution of his problem, without necessarily corresponding to any special phase of practice.

The principal products formed by the lead blast furnace are metallic lead or base bullion; matte consisting mainly of sulphides of copper, iron, and lead; and slag, which is composed principally of silica, ferrous oxide, and lime. In addition to these there may be speise resulting from the combination of arsenic and iron, when there is much of the former element in the charge. There is always the production of some flue dust, which is carried from the furnace by the rising column of gases; and owing to the volatilization of certain compounds of lead and zinc, arsenic, antimony, and other elements from the hotter portions of the furnace there is always formed a quantity of still another product called fume. The lead, matte, and slag are removed from the bottom of the furnace by tapping, while the gas, dust, and fume are drawn from the top of the furnace through the flue.

Unless the materials to be smelted are of such a nature as will give rise to excessive flue dust and volatilization losses during smelting these factors may generally be disregarded in calculating the charge. This statement does not apply, however, to sulphur and arsenic, since considerable quantities of these elements are oxidized in the furnace and escape with the gases, a point which will be more thoroughly discussed in a subsequent paragraph.

There is nearly always present in the lead furnace charge more or less copper, which for purposes of calculation may be considered as passing into the matte. Of course, some of it will enter the bullion and a little will be lost in the slag, and its concentration in the bullion will increase as its concentration in the matte increases. But for preliminary purposes, at least, the copper may be assumed to enter the matte only.

The iron, on the other hand, will pass partly into the matte and partly into the slag. Under normal conditions of operation iron is needed as sulphide as a matte constituent, and as oxide as a slag constituent.

Of other constituents of the charge that are commonly present, lime, silica, and alumina may be assumed to pass entirely into the slag; while zinc is partly volatilized, partly slagged, and in part enters the matte.

SULPHUR

One of the most uncertain factors in the operating conditions of a furnace, and at the same time a very important one, is the behavior of sulphur. A part of this element of the charge will escape from the furnace with the gases in the form of the sulphur oxides and as elemental sulphur; a part will enter the slag; and the remainder may be considered as combining with copper, iron, lead, zinc, and other metals to form the matte. The distribution of sulphur among these products depends upon many conditions, which include the chemical form in which the sulphur exists in the materials being smelted, the physical characteristics of these materials, the dimensions and lines of the furnace, the composition of the slag, and many other conditions that need not be mentioned here. It is thus evident that previous experience in smelting the materials under consideration constitutes the only reliable guide in making estimates as to the relative amounts

of sulphur that will enter the gas, matte, and slag, respectively. Even with such information at hand such estimates will sometimes be considerably in error, as has been pointed out in a preceding paragraph.

In the absence of such experience reasonable assumptions have to be made with regard to the behavior of the sulphur in the furnace. It may be assumed, for instance, that of the sulphur entering the furnace from 20 to 25 per cent will escape with the gases. The conditions within the ordinary lead furnace are of such a reducing character that no greater evolution of sulphur in the furnace gases is to be expected than this. It may be assumed that the slag produced will analyze 1 per cent sulphur, this being an average figure. After the quantities of sulphur called for by the two preceding assumptions have been deducted from that present on the charge, the remainder may be assumed to enter the matte.

MATTE COMPOSITION

The composition of the matte produced by the lead furnace is another factor of considerable uncertainty, depending as it does on the relative amounts of copper, lead, iron, zinc, sulphur, etc., that may be present in the materials charged, and also on the conditions of smelting aside from the composition of the charge. There may be very little copper and zinc in the charge, in which case the matte will consist mainly of iron and lead sulphides. It has already been noted that all of the copper of the charge may be assumed to enter the matte, and that a part of the zinc will also enter this product. A number of analyses of typical lead furnace mattes show limiting values of the most important constituents as follows:

Lead	5 to 15 per cent
Copper	1 to 15 per cent
Iron	30 to 55 per cent
Sulphur	20 to 25 per cent
Zinc	1 to 10 per cent

Of course, mattes are frequently made the constituents of which do not fall within the limits set by the above table, but the figures given will cover the general run of the lead furnace mattes ordinarily produced. It is evident that there is no particular uniformity as to matte composition, and that any assumption made without previous experience as a guide is likely to be incorrect to a greater or less degree. However, as will be seen later, the important point with reference to matte composition in so far as it affects the calculation of the charge is the ratio of iron to sulphur; and this, in the absence of excessive amounts of copper and zinc, is generally about two to one. This relation may be assumed for the ordinary conditions of lead smelting with a reasonable degree of safety. Certainly it will not lead one further astray than other assumptions of like nature.

ARSENIC AND SPEISE

Arsenic is a common constituent of ores that are smelted in the lead blast furnace, and in the main the behavior of this element is similar to that of sulphur. A part of the arsenic that enters the furnace will combine with iron forming arsenides of various compositions, depending on the conditions of smelting. The percentage of the arsenic charged that enters into such combinations is also quite variable and depends on the composition of the slag, the rate of smelting, etc. It is frequently found that the iron and arsenic have combined in proportions corresponding to the formula Fe_2As_3 , containing 65.2 per cent of iron, which yields a ratio of iron to arsenic of almost two to one. In view of the manifest difficulties in the way of predetermining the behavior of arsenic in the furnace charge this relationship between iron and arsenic may as well be

assumed as any other. So that if the arsenic is present in such quantities as to impose the necessity of including it in the calculation of the charge, some such quantity as 60 to 80 per cent of the arsenic charged may be assumed to combine with iron in the ratio of two parts of iron to one of arsenic. The iron arsenide gives rise to another furnace product known as speise, which may or may not be distinguishable from the matte, depending on the relative quantities of matte and arsenide produced. Mattes will dissolve metal arsenides up to certain limits. Hence with a high matte fall and with little arsenic on the charge the speise formed may not make its appearance as such.

SLAG-FORMING CONSTITUENTS

Silica, ferrous oxide, and lime are the principal slag-forming constituents, and it is with the proper adjustment of these that the ordinary charge calculation deals. When the amounts of zinc, alumina, etc., in the materials to be smelted are comparatively low it is customary to assume that the slag to be produced will consist of a total of 90 per cent of the three principal oxides, the other 10 per cent being composed of alumina, zinc, sulphur, lead, and other elements or compounds generally present in the slag to a greater or less degree. When the amounts of these minor slag-forming constituents in the charged materials are very low, it may be well to assume that the three principals will constitute 95 or 96 per cent of the slag. On the other hand, it may in some cases be necessary to assume that the silica, ferrous oxide, and lime will constitute only 85 per cent of the slag, and that the remaining 15 per cent will be composed of the other substances. The assumption that the three principal oxides will constitute a certain percentage of the slag as produced has to be based entirely upon an estimate of the amounts of the minor slag-forming constituents present. This estimate may be, and usually is, somewhat incorrect, and in the slag as it comes from the furnace the three principal oxides are not present in the exact percentages that have been calculated. But in general the desired ratios of these oxides each to the other will be preserved, and this, in the absence of unusual conditions, will yield a satisfactory slag.

Some metallurgists in calculating their charges follow certain rules that take into account the alumina and zinc oxide and include these constituents in the slag analyses. But it would appear that for students such considerations may well be dispensed with, the first efforts, at least, being concentrated on the adjustment of silica, ferrous oxide, and lime, and the other oxides and compounds being regarded as diluents.

SLAG COMPOSITION

The proportions of the three principal slag-forming constituents to be employed in practice are determined by such a variety of technical and commercial considerations that to discuss them in detail falls outside of the scope of the present paper. It may be well, however, to note a few of the more important factors that govern the selection of a slag.

When the prevailing ore supply of the smelter is silicious in character and basic fluxes are scarce and expensive, the use of an acid or silicious slag is indicated. Of course the reverse of this proposition is also true. Likewise, the relative costs of limestone and iron flux may become determining factors in the selection of the slag. Aside from these and other commercial considerations there are a few more technical points that it may be well to mention. It is generally agreed that in smelting materials rich in zinc the lime in the slag must be kept low and the iron correspondingly high. Zinc

oxide and any considerable quantity of magnesia are also quite incompatible. Alumina may be present to the extent of about 10 per cent without complicating matters greatly, unless at the same time the amount of zinc or magnesia is high. Slags rich in iron and poor in silica apparently have a greater tendency to allow the formation of furnace accretions than do those that are higher in silica and with a greater ratio of lime to iron. These and many other factors must be considered in connection with the selection of a slag, and operating experiences bearing on the point might be cited without end. But for the work at hand, which is the calculation of the charge rather than the selection of the slag, it appears sufficient to state that the general intention in choosing a slag for a particular set of conditions is to employ the one that will yield the best commercial results. The student should bear this point well in mind—dollars and cents constitute the ultimate products of the smelter. But even in the plant it is not always possible to select in advance the slag composition that will yield the best results as measured by this standard, and far less is such a selection possible in the class room. It, therefore, again becomes necessary to employ in class-room calculations such assumptions as appear reasonable in view of the data at hand, and to let the matter rest with that.

While it is possible to vary the relative amounts of silica, ferrous oxide, and lime in the slag within comparatively wide limits, in accordance with the above outlined factors, yet it has been demonstrated by experience that there are practical limitations to such variations. The silica in successful lead furnace slags is generally not less than 28 nor more than 40 per cent. The ferrous oxide varies between 28 and 50, and lime between 10 and 30 per cent. The oxygen ratios of such slags are generally not far from unity, but slags of somewhat greater acidity than corresponds to this ratio are more common than those of less. Modern practice with large furnaces has frequently shown that what were formerly thought to be absolute limitations as to slag composition may sometimes be overstepped, the fusibility and fluidity of the slag under the conditions of its production being the ultimate guides as to its fitness. The ideas that precise ratios between lime and ferrous oxide and that a definite ratio of oxygen in the acids to oxygen in the bases had to be preserved in order to secure a good slag, if they were ever held, have now given way. Both theory and practice have contributed to this end. Laboratory studies have shown that liquid slags may be regarded as igneous solutions of their constituent oxides with the possible presence of associated compounds, rather than as fused compounds or solutions of such that might result from the combination of the oxides. At the same time commercial conditions have frequently prompted the trial of slag compositions that differed considerably from those previously employed, and where such trials met with success new possibilities as to slag composition were established.

Without discussing further the relative advantages and disadvantages of different slags, the compositions of a number of typical lead furnace slags are given in Table I. The names by which the slags are designated are derived from the exact or approximate ratios of lime to ferrous oxide, and in each case the three constituents total 90 per cent as specified in the left-hand columns of figures, and 96 per cent in the right.

Note.—The figures representing silica, ferrous oxide, and lime in the left-hand columns total 90 per cent; those in the right-hand columns total 96 per cent.

The above list of slags does not by any means include all of the compositions that have been successfully em-

TABLE I—TYPICAL LEAD SLAGS WITH SILICA, LIME, AND FERROUS OXIDE, TOTALING 90 AND 96 PER CENT

Name	SiO ₂ , Per Cent		FeO, Per Cent		CaO, Per Cent	
Quarter slags.....	28	30	50	53	12	13
	30	32	48	50	12	13
	32	34	47	50	11	12
Half slags.....	30	32	46	43	20	21
	32	34	38	40	20	21
	34	36	37	40	19	20
Three-quarter slags...	33	35	33	35	24	26
	37	39	30	32	23	25
Whole slag.....	34	36	28	30	28	29

ployed in lead smelting. No attempt will be made here to include all of the possibilities, nor to discuss in detail the conditions under which each slag may be properly employed. The compositions that are given, however, are representative and will serve the present purpose.

In order to demonstrate the methods of charge calculation that have been found useful in class room work several graded problems will be stated and solved. These will increase somewhat in complexity from the first to the last, and in the solution of them most of the chemical and metallurgical principles involved in blast furnace smelting for lead are brought before the student. It may be added with much truth that until the student is able to solve such problems with a certain degree of speed and accuracy he can hardly be considered as being familiar with these principles.

PROBLEM I.

Materials of compositions shown in the following table are to be charged to the lead blast furnace.

Material	SiO ₂ , Per Cent	Fe, Per Cent	CaO, Per Cent	S, Per Cent
Silicious ore	40.0	10.0	...	4.0
Iron ore	10.0	60.0	...	1.0
Limestone	5.0	5.0	50.0	...
Coke	5.0	1.0	1.0	1.5

Conditions and Assumptions.—It is desired to produce a slag that will contain silica 33 per cent, ferrous oxide 33 per cent, and lime 24 per cent, leaving 10 per cent to be formed by the various minor constituents not specified in the table. The amount of coke to be employed is 14 per cent of the charge. By the word charge is meant the total weight of ores and fluxes exclusive of the coke.

Assume that 20 per cent of the sulphur charged to the furnace will escape with the gases, and that the slag when produced will contain 1 per cent of sulphur. Assume that the remainder of the sulphur will enter the matte and require twice its weight of iron in forming this product.

Required.—Determine the amounts of limestone, iron ore, and coke to be smelted with 1000 lb. of the silicious ore in order to comply with the conditions and assumptions set forth above.

Notes.—It will be seen that in this first problem no account is taken of the amounts of lead and copper in the materials to be smelted. It is presumed that lead is present in the silicious ore in sufficient quantity to warrant smelting that material with the necessary fluxes. But in order to simplify matters in this first problem the lead will be omitted, and attention directed toward the proportioning of the charge in order to produce the desired slag and the assumed matte.

In the table the slag forming constituents of the coke ash are specified as percentages of the coke as a whole. Of course, these constituents are generally determined on samples of the coke ash, but in calculating the charge it is somewhat more convenient to have the analysis stated as shown.

The iron in the materials to be smelted is specified in terms of metallic iron, while the composition of the slag with respect to iron is stated in terms of ferrous

oxide. This is on account of the fact that it is necessary to consider not only that part of the iron in the charged materials which enters the slag, but also to take into account the iron that enters the matte. It will presently be seen that for purposes of calculation it is a little more convenient to have analyses stated in terms of iron rather than ferrous oxide.

Solution.—A good starting point for such a problem as this is to calculate the ratios of the slag constituents each to the other. In this case it will be most convenient to determine the amounts of iron, lime, and sulphur that will accompany a unit weight of silica in the finished slag. Silica is chosen as the standard because an inspection of the analyses shows that silica is the predominating slag constituent in the silicious ore, and it is for the silica of this material that iron will have to be supplied by the iron ore and lime by the limestone. The slag is to consist of silica 33 per cent, ferrous oxide 33 per cent, and lime 24 per cent; there will also be present 1 per cent of sulphur. Therefore, for each unit weight of silica in the slag there will be present other constituents as follows:

$$\text{Fe} = \frac{33\% \text{ FeO} \times 56 \text{ (atomic weight of Fe)}}{33\% \text{ SiO}_2 \times 72 \text{ (molecular weight FeO)}} = \frac{7}{9} = 0.778$$

$$\text{CaO} = \frac{24\% \text{ CaO}}{33\% \text{ SiO}_2} = 0.727$$

$$\text{S} = \frac{1\% \text{ S}}{33\% \text{ SiO}_2} = \frac{1}{33} = 0.0303$$

That is to say, for each pound of silica present in the slag as produced there must be 0.778 lb. of iron, 0.727 lb. of lime, and 0.0303 lb. of sulphur. With the aid of these factors, it will be a simple matter to determine whether or not the charge is properly balanced after the amounts of the different materials have been estimated. The factors will also be of service in making the estimates.

Next, let a charge sheet be drawn up according to the following form.

CHARGE SHEET, PROBLEM 1.

	Material Weight	Silica		Iron		Lime		Sulphur	
		Per Cent	Wt.	Per Cent	Wt.	Per Cent	Wt.	Per Cent	Wt.
a—Silicious ore	1000	46.0	460	10.0	100	...	...	4.0	40.0
b—Iron ore...	435	10.0	43	60.0	259	...	...	1.0	4.9
c—Limestone	710	5.0	36	5.0	36	50.0	355	...	...
d—Coke, 14%...	307	5.0	15	1.0	3	1.0	3	1.5	4.6
e—Totals	...	...	500	...	430	...	358	...	49.5
f—Silicious ore	1000	...	400	...	100	...	...	...	40.0
g—Iron ore...	500	...	50	...	300	...	...	...	5.0
h—Limestone	725	...	36	...	36	...	363	...	...
i—Coke, 14%...	312	...	16	...	3	...	3	...	4.7
j—Totals	...	...	502	...	439	...	366	...	49.7

In line *a* there is entered 1000 lb. of the silicious ore that is to be smelted. The figures representing the analysis of this material are entered in the spaces provided, and the weights of silica, iron, lime, and sulphur contained in 1000 lb. of the ore are calculated and entered in their respective spaces. In lines *b*, *c*, and *d* are entered the analyses of the iron ore, limestone, and coke, respectively. The amounts of the last three materials have not yet been estimated, so these lines of the sheet are not to be completed until the estimates are made.

In order to estimate the approximate amount of iron ore that must be smelted with 1000 lb. of the silicious ore the following procedure may be adopted. The silicious ore contains 40 lb. of sulphur. According to the assumption as to the disposal of this sulphur in the furnace, 20 per cent will escape with the gases, leaving 80 per cent to enter the matte and slag, 40 lb. $\times 0.80 =$

32 lb. At this point it is possible to estimate only that sulphur which will enter the slag to be formed by the silica of the ore itself. Of course, there will be more silica on the charge than the 400 lb. shown in line *a*, but then too there will be more sulphur than this line shows. So, as a preliminary estimate it will be proper to divide the amount of silica in the silicious ore by 33 in order to find the amount of sulphur of that ore which will enter the slag to be produced with that silica. 400 lb. of silica $\div 33 = 12$ lb. of sulphur to the slag. Considering this ore alone, therefore, and balancing its constituents against each other, the amount of its sulphur that will enter the matte is seen to be 32 lb. — 12 lb. = 20 lb. This sulphur will require twice its weight of iron or 40 lb. The iron shown in line *a* amounts to 100 lb., of which 40 lb. will be required by the sulphur of the ore to form matte, thus leaving 100 lb. — 40 lb. = 60 lb. of iron that will enter the slag. According to the previously calculated slag ratios 0.778 lb. of iron must be present with each pound of silica. The 60 lb. of iron will therefore fulfil the iron requirement of 60 lb. $\div 0.778 = 77$ lb. of silica. The amount of silica in the silicious ore is 400 lb., and with 77 lb. of it provided with iron in the necessary ratio, there remains 400 lb. — 77 lb. = 323 lb., the iron for which must come from an external source—the iron ore.

Consider 100 lb. of the iron ore. It contains 10 lb. of silica, which will require for slag forming purposes 10 lb. $\times 0.778 = 8$ lb., approximately, of iron. Hence of the 60 lb. of iron present 8 lb. must be allowed to accompany the silica of this material into the slag. There is also sulphur present, which will require some of the iron for matte. The amount so required, however, will be small and can be disregarded for the present. The iron requirement of the 323 lb. of silica not already provided with iron will be 323 lb. $\times 0.778$, and if this quantity is divided by 60 lb. — 8 lb. = 52 lb. of available iron in the iron ore, and multiplied by 100, the result will be the approximate amount of iron ore required with 1000 lb. of the silicious ore. Thus,

$$\frac{323 \text{ lb.} \times 0.778 \times 100}{52} = 481 \text{ lb.}$$

At this point the natural question for the student to ask is, "Why make such a fuss about making an estimate of the amount of iron ore required, if the result, when it is obtained, is nothing but an approximation, and perhaps a rough one at that?" The answer to this question is that much more time and space are required to write out the estimate and to explain the way in which it is made than are required by the operation itself. In fact, if the reader will go over the estimate again he will see that, with the exception of solving the last expression, the entire operation can be performed mentally and without the necessity of touching pencil to paper, except to jot down occasional figures for reference; and the final relation can be solved by one setting of the slide rule. It is the intention to make all such estimates of such an approximate character that only quick mental calculations, perhaps concluded by a slide rule setting, are required.

In order to demonstrate the simplicity of the operation, the preceding work may be summarized as follows:

Consider the figures of line <i>a</i> :	
Sulphur to matte and slag = 40 lb. $\times 0.80 =$	32 lb.
Sulphur to slag = 400 lb. silica $\div 33 =$	12 lb.
Sulphur to matte =	20 lb.
Iron on the charge from line <i>a</i> =	100 lb.
Iron accompanying 20 lb. sulphur to matte = 2×20 lb. =	40 lb.
Iron for slag =	60 lb.
Silica present in ore =	400 lb.
Silica provided with iron = 60 lb. $\div 0.778 =$	77 lb.
Silica not provided with iron =	323 lb.

Consider the analysis of the iron ore on basis of 100 lb. of this material, line *b*.
 Iron present in 100 lb. of the ore = 60 lb.
 Iron required by 10 lb. silica = 10 lb. $\times$ 0.775 = 8 lb.
 Iron available for slag forming, neglecting sulphur = 52 lb.
 Amount of iron ore required to supply iron for 323 lb. of silica
 $323 \text{ lb.} \times 0.775 \times 100 = 481 \text{ lb.}$
 52

On account of having neglected the sulphur of the iron ore 481 lb. of this material would prove insufficient for the excess silica of 1000 lb. of the silicious ore; 485 lb. would be more nearly the required amount. Furthermore, while an examination of the analysis of the limestone shows that the silica of this material is provided with slightly more iron than the slag ratio calls for, the coke is seen to have a considerable excess of silica over iron. Hence, after the necessary amounts of limestone and coke are provided, the 485 lb. of iron ore will not furnish enough available iron for the silica thus added, it having been calculated for the silicious ore alone. On this account it might be well to make an addition to the 485 lb. of iron ore in order to bring the estimated amount nearer to the actual requirement of the entire charge, and with a little more experience that is what ought to be done. But without the experience the addition might be made as the result of a somewhat wild guess. It is better for the present to enter 485 lb. of iron ore in line *b* and see how things work out.

Having entered this amount of iron ore, and calculated and entered the amounts of silica, iron, lime, and sulphur thus added to the charge, an estimate of the amount of limestone required may be made. This operation is even simpler than the iron ore estimate, because the lime may be assumed to enter the slag completely; none of it need be deducted for the matte. The amount of silica now shown by the charge sheet is 400 lb. in line *a* and 49 lb. in line *b*, making 449 lb. According to the slag ratio, the lime requirement of 449 lb. of silica is 449 lb. $\times$ 0.727. It will be noted at this point that neither line *a* nor line *b* contain any lime, and for this reason the lime for the entire 449 lb. of silica now known to be present has to be supplied by the limestone. Considering the analysis of the limestone shown in line *c*, 100 lb. of this material is seen to contain 5 lb. of silica, which will require 5 lb. $\times$ 0.727 = 4 lb. approximately of lime. The excess of lime over silica in the limestone is therefore seen to be 50 lb. — 4 lb. = 46 lb. in each 100 lb. of the material. The amount of limestone required to supply lime for 449 lb. of silica according to the slag ratio is accordingly

$$\frac{449 \text{ lb.} \times 0.727 \times 100}{46} = 710 \text{ lb.}$$

Again it will be observed that this amount of limestone is not sufficient for the entire charge. It will provide the silica of the silicious ore, of the iron ore, and of the limestone itself with lime in the proper ratio. But it has already been pointed out that the amount of iron ore entered on the charge sheet will be low, and also it may be seen that the lime in the coke is too low to maintain with the silica of that material the proper ratio. Hence, it is to be expected that the ultimate amount of limestone will be more than 710 lb. However, this amount will be entered on the charge sheet in line *c*, and the amounts of silica, iron, and lime will be calculated and entered.

The estimate of the limestone could be reduced to a very small space as was that of the iron ore, but it will be unnecessary to do this. It should be clear that only the solution of the last expression requires anything more than mental arithmetic.

The charge is now composed of silicious ore 1000 lb., iron ore 485 lb., and limestone 710 lb. Lines *a*, *b* and *c*

of the charge sheet have been completed. Now, if the coke is to be 14 per cent of the charge, then the amount of coke will be (1000 + 485 + 710) lb. $\times$ 0.14 = 2195 lb. $\times$ 0.14 = 307 lb. This amount is entered in line *d*, and the amounts of the various constituents that it contributes are computed and entered.

The columns of figures showing the weights of the respective constituents are now added, and the totals are entered in line *e* of the charge sheet. It will be observed that in each case the weights of silica, iron, and lime have been computed only to the nearest pound, while those of sulphur have been carried to 0.1 lb. The reason for this is that the first three substances are present in relatively large amounts as compared with the sulphur, so that computations to the nearest pound in the one case and to the nearest 0.1 lb. in the other yield results of about the same degree of precision.

The charge may now be tested to determine whether or not the various constituents are present in amounts necessary to satisfy the assumptions and conditions specified in the statement of the problem. It is to be expected, as has been previously pointed out, that both the lime and the iron will be found to be present in insufficient quantities. But by balancing the charge the amounts of the deficits of these constituents can be determined, and increases in the iron ore and limestone can be made accordingly. The following outline will illustrate the method of performing this operation.

Considering the totals entered in line *e*:

Sulphur to matte and slag = 49.5 lb. $\times$ 0.80 =	39.6 lb.
Sulphur to slag = 500 lb. $\div$ 33 =	15.1 lb.
Sulphur to matte after deducting gas and slag losses = ..	24.5 lb.
Iron on charge for matte and slag =	430 lb.
Iron to matte with sulphur = 24.5 lb. $\times$ 2 =	49 lb.
Iron for slag =	381 lb.
Iron required by 50 lb. silica = 500 lb. $\times$ 0.775 =	389 lb.
Deficit of iron =	8 lb.
Lime for slag =	358 lb.
Lime required by 500 lb. of silica = 500 lb. $\times$ 0.727 =	364 lb.
Deficit of lime =	6 lb.

It is thus seen that the charge as shown by the first four lines of the charge sheet contains neither enough iron nor lime to produce the desired ratios of these constituents with the silica present, and to provide iron for the sulphur of the charge that will enter the matte.

In order to supply sufficient quantities of the deficient materials the amounts of iron ore and limestone must be increased. But what is the proper amount to add to each? It will be remembered that the iron ore contains approximately 52 lb. of available iron in each 100 lb. Therefore the approximate amount of iron ore to add will be found by the expression:

$$\frac{8 \text{ lb. (deficit of iron)} \times 100}{52} = 15 \text{ lb.}$$

In a similar manner the deficit of 6 lb. of lime is to be supplied by the limestone, which contains 46 per cent of lime in excess of the amount required to supply its own silica in the proper ratio. The amount of limestone to add is therefore

$$\frac{6 \text{ lb. (deficit of lime)} \times 100}{46} = 13 \text{ lb.}$$

It is well to increase this amount to 15 lb. for two reasons. In the first place it is well to keep the amounts of materials charged in terms of figures ending with 0 or 5, this for ease in computation. In the second place the addition of iron ore that is to be made will increase the amount of silica present, which is not provided with the necessary quantity of lime, by 1.5 lb. The addition of 2 lb. of limestone to the 13 lb. estimated will approximately correct this condition.

In making these changes in the charge sheet the first amounts may be erased and the new ones entered in their places. But from this procedure there generally results a more or less begrimed sheet, and also, in the event of a third or fourth trial being necessary, it will be found more convenient to have the results of preceding trials in evidence on the sheet. Consequently, the new amounts are best entered in a new set of lines below the first, the entries being made in their respective columns, of course. In line *f* enter 1000 lb. of the silicious ore and the corresponding amounts of silica, iron, and sulphur. In line *g* enter 485 lb. + increase of 15 lb. = 500 lb. of iron ore, and compute and enter the corresponding amounts of this ore's components. In line *h* enter the 710 lb. of limestone + its increase 15 lb. = 725 lb.; compute and enter the amounts of components of this material. The coke will be increased in proportion to the other increases, the new weight being $(1000 + 500 + 725) \text{ lb.} \times 0.14 = 2225 \text{ lb.} \times 0.14 = 312 \text{ lb.}$ This amount might be cut to 310 lb. for convenience in calculation, but in this case it will be entered as it is, and the weights of components of the coke calculated from the weight 312 lb. See line *i* of the sheet.

Now, in line *j* the new totals of silica, iron, lime, and sulphur are entered, and the correctness or otherwise of the revised charge is determined as before. The outline of this process follows.

Considering the totals of line *j*,

Sulphur to slag and matte = 49.7 lb. $\times 0.80 =$	39.8 lb.
Sulphur to slag = 502 lb. $\div 33 =$	15.2 lb.
Sulphur to matte after deducting slag and gas losses =	14.6 lb.
Iron on charge for matte and slag =	439 lb.
Iron to matte = 14.6 lb. sulphur to matte $\times 2 =$	49 lb.
Iron for slag =	390 lb.
Iron required by 502 lb. silica = 502 lb. $\times 0.778 =$	390 lb.
Lime on charge for slag =	366 lb.
Lime required by 502 lb. silica = 502 lb. $\times 0.727 =$	365 lb.
Excess of lime over that required =	1 lb.

The balance in this case is satisfactory, that of iron being exact to the nearest pound, and that of lime being within 1 lb. The charge may therefore stand as it was last written, silicious ore 1000 lb., iron ore 500 lb., limestone 725 lb., and coke 312 lb.

The problem that has just been solved is a very simple one, purposely made so in order to illustrate the principles involved in its solution by the method adopted. Of course, the available flux calculations could have been carried throughout, and the amounts of iron ore and limestone required by each material of the charge could have been so determined. But such a procedure would have taken considerably more time and effort than did the one adopted, and the result would have differed in no way from the one obtained.

It may appear that the method of solution employed was a rather "long winded" affair, and, in truth, the description of it does occupy a considerable amount of space. This is due, however, not to the actual amount of work involved, but to the elaboration of details that was attempted in order to make each step in the process perfectly clear. Subsequent problems will illustrate this point, because in solving them it will be unnecessary to enter into such detailed statements.

THE MEANING OF SLAG RATIOS

Before proceeding to the next problem it may be well to deal with a point that frequently proves a stumbling block in the way of the student's understanding of the object of the game in which he is engaged. This point is best outlined by several questions that are almost invariably put when this subject is taken up in the classroom. After the silica has been supplied with iron why is it also necessary to provide lime for it? Does

not the iron of the limestone require lime as well as the silica? Why does the silica in the slag have to be provided with a certain quantity of sulphur, what does it do with this sulphur? These and other questions of like nature are sure to arise, and they are apparently evolved from the idea that a definite chemical appetite of the silica for various other things is the point at issue. This appetite of the silica having been satiated with iron to the full extent of the slag ratio, should not then demand a quantity of lime by way of dessert. But it does, and how can that be? Because the so-called chemical appetite of the silica does not enter into the question at all. Simple arithmetical ratios are the factors involved in this calculation. The only chemistry that appeared was the relation between ferrous oxide and iron, and aside from this there is no chemistry whatever in such a charge calculation.

It is desired to produce a slag that will contain silica 33 per cent, ferrous oxide 33 per cent, and lime 24 per cent. At the same time it is assumed that the slag will contain 1 per cent of sulphur. Simply for convenience in calculation a unit weight of silica was selected, and the quantities of iron, lime, and sulphur that would be simultaneously present with this unit of silica in a slag of the above composition were computed. Any of the other components might have been selected as the standard, and the final result would have been precisely the same. It so happens that in the slag under consideration the components bear this relation to each other:

silica : iron : lime : sulphur = 1 : 0.778 : 0.727 : 1/33.

Now, if the iron on the charge is adjusted to the silica in the proper ratio, and if the lime is also adjusted to the silica in its proper ratio, will not the lime be adjusted to the iron in proper ratio? The answer to this question explains why, in figuring the amount of lime in excess of silica in the limestone, it was unnecessary to allow lime for the iron that was also present. Of course, that iron upon entering the slag would have to be accompanied by lime in proper quantity. But this same lime will also serve to establish proper relations with a certain quantity of silica, which in turn will require the presence of a quantity of iron determined by the slag ratio of silica to iron. Similarly, if 1/33 unit of sulphur is present in the slag for each unit of silica, and if lime and iron are present in definite quantities with reference to this unit of silica, then the proper ratios of iron and lime to the sulphur will be maintained. Will they not? In other words, the object sought in the charge calculation is the establishing of definite mutual ratios between the constituents of the slag—simply this and nothing more. Remember, the ratios are not independent, but each is related to the others in a definite manner,

(To be concluded.)

New Steel Mill in Chile.—The high cost of steel since the outbreak of the European war has started a new steel industry in Chile on a small scale. The raw material used is the old iron, formerly exported to Europe. The skilled labor consists of Spaniards, while the Chileans serve as apprentices. Chilean coal is used as fuel. It necessitated the special building of a foundry for the making of the necessary machinery. The machines to be used are of European pattern. The products of the mill are bars, plates, angles, tees, construction steel, carriage parts, nuts, bolts, nails, tires, etc. The steel produced is 20 per cent cheaper than the imported product. The mill is in operation, and, while the plant is still small, it will undoubtedly serve as the foundation for a big industry, as the Chileans are an aggressive and energetic people.

Countercurrent Decantation*

By Luther B. Eames

Mill Superintendent, Hollinger Consolidated Gold Mines, Ltd.

The recovery of dissolved gold from slime pulp in the cyanide process was first accomplished by intermittent decantation. This simple process consists in mixing with the pulp containing the values in solution, a solution of lower gold content, settling the mixture in a tank and decanting the clear supernatant fluid. The thick pulp remaining in the tank is pumped to a second tank together with more barren solution and again settled and decanted. After several repetitions of this operation, values are so far reduced that further washing is not profitable. The gold recovery of this process is high, but the plant required is bulky, labor cost is high and the amount of solution to be precipitated is excessive.

HISTORICAL DATA

As early as 1901, a plant was built in the Black Hills of South Dakota by John Randall, employing the same principles but attempting to make the process continuous by substituting for flat-bottomed tanks, cones which operated continuously, receiving a constant feed and discharging a steady stream of thickened pulp. These cones were operated in series, the thick underflow of the first one forming, with a stream of diluting solution, the feed to the second cone of the series. Barren solution was added to the tank immediately preceding the discharge tank and, after being slightly enriched by the low-grade pulp in this tank, overflowed to form a diluting solution again for the richer feed entering the third tank from the end of the series, and so on back to the richest tank of the series. Clear water was used for the wash in the final tank. This is the principle on which all successful countercurrent decantation plants operate at the present time, but Randall's plant was not successful because of mechanical difficulties in getting a continuous thick discharge from his cone tanks. A similar plant was built in South Africa, although there the washes were not repeatedly used, as in Randall's case, but were precipitated after each contact with the ore. This also was abandoned because of mechanical difficulties and the cost of precipitating the large quantities of solution that had to be used. For a number of years the process was not used, and it was not until the introduction of the Dorr thickener that the minds of metallurgists began to turn again to the continuous decantation principle.

In 1910, two decantation plants were built making use of flow sheets similar to that used by Randall 9 years before, but substituting Dorr thickeners for the cones. One of these was at Mocorito in Sinaloa, Mexico, and was installed under the direction of C. Dupre Smith, while the other was designed by J. V. N. Dorr, assisted by the writer, for the Vulture Mines Co. of Wickenburg, Ariz. While perhaps not perfect at first, both of these pioneer plants were so successful as to encourage fur-

ther installations, few and scattering at first but in considerable numbers during the past three years.

THEORETICAL CONSIDERATIONS

In view of this increasing importance, the following discussion of the principles and characteristics of the process is offered. For the purpose of investigation a simple yet typical flow sheet has been selected. This is shown in Fig. 1.

This flow sheet assumes that crushing is done in solution, the overflow from the tank T_2 being used for the crushing solution. This crushing solution leaves the grinding circuit with the ground pulp and enters T_1 , and that part which does not pass to the agitators with the pulp overflows T_1 and goes to precipitation. After depositing its gold contents, it is used to dilute the underflow of T_2 as it enters T_1 . The overflow of T_1 is also mixed into the feed to T_2 . The overflow of T_1 mixes with the underflow of T_2 to form the feed to T_3 , and so forth, as indicated in the flow sheet. At each succeeding mixture the solution meets a pulp of higher dissolved content than itself and is enriched while the pulp is correspondingly impoverished. The pulp at each step approaches the discharge end of the mill while the solution goes to the feed end—hence countercurrent decantation.

VARIABLES AFFECTING DECANTATION PROCESS

The principal variables that may affect the efficiency of the process are:

1. Grade of ore.
2. Ratio of solution precipitated to ore treated.
3. Thickness at which pulp can be discharged.
4. Cost of chemicals.
5. Rapidity of dissolving, and the place in the circuit where it takes place.
6. Efficiency of precipitation.

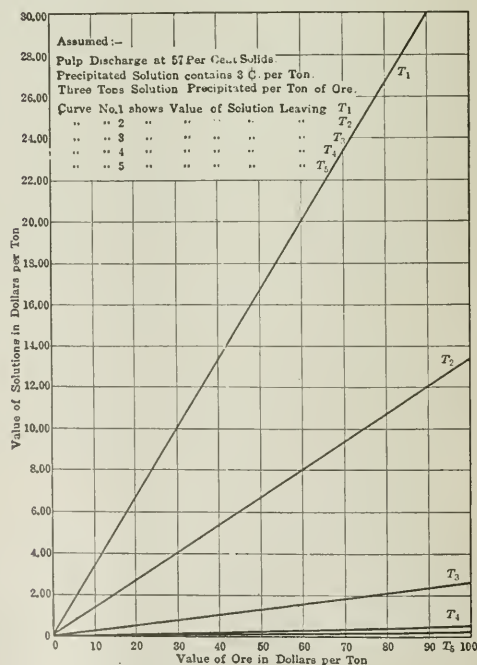
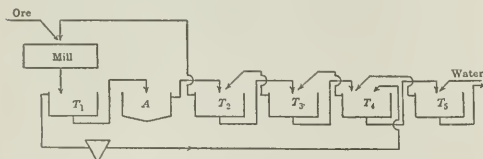


FIG. 1—TYPICAL FLOWSHEET OF COUNTER-CURRENT SYSTEMS

FIG. 2—EFFECT OF VARIATIONS IN GRADE OF ORE TREATED

*A paper to be presented at the New York Meeting of the American Institute of Mining Engineers in February, 1917.



Since the decantation process is one involving volumes and dilutions, it is possible to calculate accurately what distribution of values should take place under any given set of conditions. As far as possible, each one of the above variables has been mathematically considered independently of the rest and the results have been plotted.

The effect of variations in the grade of ore is shown in Fig. 2 and scarcely needs comment. In practice, of course, no such increase as is shown in the gold-solution curve would ever be allowed to take place on account of the difficulty of precipitating such high-grade solution and the danger of leakage, but the graph shows conclusively that all solutions increase in value in direct proportion to the increase in the grade of the ore and that the higher-grade solutions increase at a much more rapid rate than the final washes.

The important part played by the ratio of solution precipitated to ore milled is shown in Fig. 3. For the particular grade of ore considered, which in this case was \$10 recoverable per ton, with precipitation to 3 cents, the economic ratio may be roughly determined by inspection of the lowest curve, which represents the value of the solution leaving the last tank of the series with the tailing. It will be noted that the loss in gold increases very fast as the amount of solution precipitated is decreased, while after a certain point the increased recovery due to increasing the volume precipitated is very slight.

The final choice of the exact ratio to be used must be influenced by the cost of precipitation, which is mainly the cost of zinc. To show clearly the effect of precipitation cost on the economic precipitation ratio, Fig. 4 was plotted. I have considered it safe to assume that the cost of increasing the amount precipitated is due to the additional zinc used. The loss in dissolved gold and the cost of the zinc used in precipitation are both

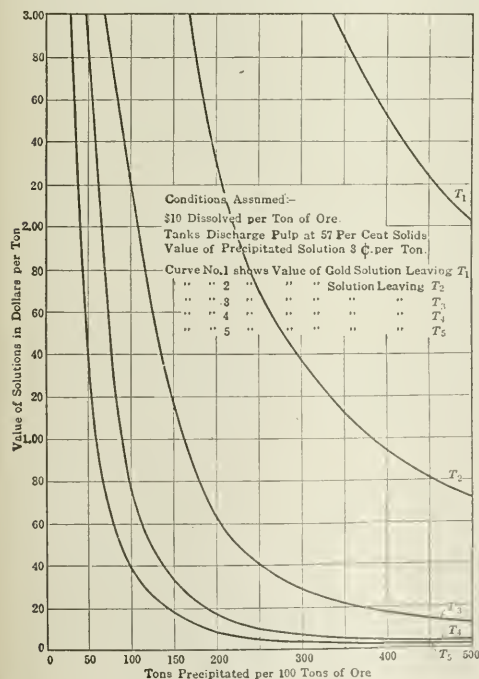


FIG. 3—EFFECT OF VARIATION IN THE RATIO OF SOLUTION PRECIPITATED TO ORE TREATED

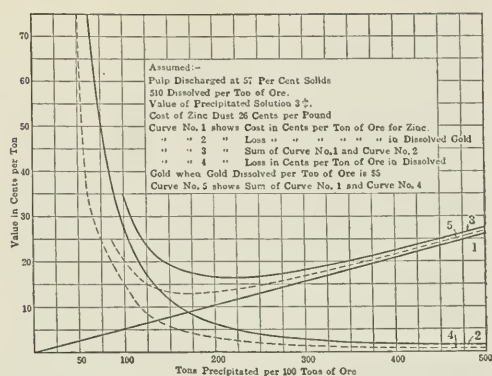


FIG. 4—METHOD OF DETERMINING THE PROPER RATIO OF SOLUTION PRECIPITATED TO ORE TREATED

plotted to the same scale in cents per ton of ore. By adding the ordinates of these two curves a third is formed which represents the total loss in gold and zinc. The lowest part of this curve represents the economical range and indicates that for a \$10 ore, under the conditions assumed with zinc at 26 cents, from 200 to 250 tons should be precipitated per 100 tons of ore treated. In dotted lines are shown the corresponding curves for a \$5 ore under similar conditions. In this case the range is from 150 to 200 tons. While there is a considerable range within which practically identical results may be expected, it is apparent that each operator should figure out for his own conditions just what his range is.

The next, and one of the most important variables to be considered, is the thickness, or percentage of solids,

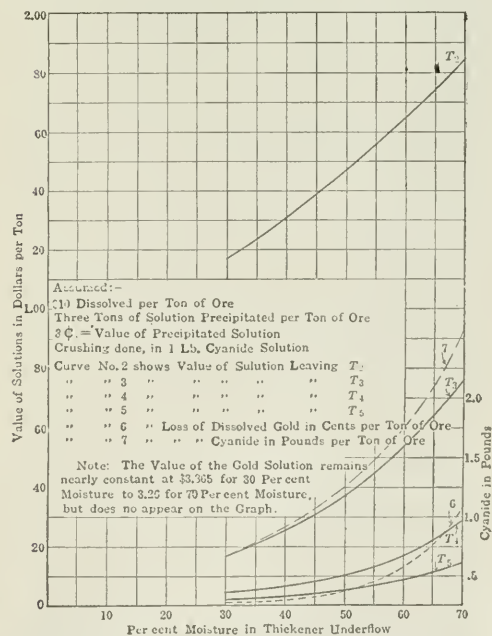


FIG. 5—EFFECT OF VARIATIONS IN THE PERCENTAGE OF MOISTURE IN THE THICKENER UNDERFLOW

to which pulp can be settled. In Fig. 5 the values of the various overflows have been plotted so as to show the effect of variations in the moisture in the underflows. The full-line curves represent the values of the solutions—that is, they are shown as per ton of solution—but in calculating losses per ton of ore, the ratio of the solution to the ore present must be considered. The loss in dissolved gold per ton of dry ore for the last tank has, therefore, been plotted in a separate curve, and it is this curve which should be given the most serious attention in determining the suitability of an ore for decantation. The moisture in the pulp also has a direct bearing on the cyanide loss, which is also shown in Fig. 5. This has been shown in pounds rather than in cents, because solution strength and the price of cyanide both affect its value. Enough is shown, however, to make it plain that there is a very decided limit to the density of the pulp that can be handled economically, and one is forcibly reminded that the cyanide strength should be kept as low as possible. Operators as a rule seem to be inclined to “play the game safe” as regards solution strength, and it is probable that in many cases cyanide could be saved without any considerable loss in gold by using solutions of a lower strength.

In making the calculations upon which the foregoing curves are based, it was assumed that 75 per cent of the gold was dissolved in the grinding department and the remaining 25 per cent in the agitators. This is, of course, an approximation which cannot be accurate, and even with the cleanest ores some gold is dissolved in passing through the tanks following the agitators. This is a condition that has always been met, no matter what the method of recovering the dissolved value. Changing solution during agitation has been practised for years in the treatment of silver ores, and in the treatment of concentrates at Goldfield with a view to reducing this lag of dissolving. I have also found that on Goldfield ore, pulp from the final agitators, reagitated without change or addition of solution, would give up no more gold, while reagitated filter tails from the same ore would show a distinct reduction. The same condition exists in the pulp fed to decantation plants, and there is little doubt that some dissolving takes place even in the last tanks of the series. Some of this value is lost, particularly that freed near the final discharge, but much is recovered that would probably not be won by any other method. The superintendent of one of the decantation plants treating Tonopah ore informed me that his sampling indicated that the additional dissolving taking place in his plant was sufficient to offset his entire dissolved loss and 3 cents per ton additional.

Any considerable dissolving during decantation will be indicated by a difference in the assay value of the solution in the underflow of the tanks as compared with the overflowing solution. In practice there is always more gold per ton in the underflow solution than in the overflow of any given tank, but in the ores of Porcupine district this difference is very small. Other causes may, and no doubt do, tend to produce this difference between the overflow and the underflowing solution. Adsorption is probably the most important and perhaps the least understood of these. In the case of the ores of the Porcupine district this phenomenon is of small importance, as the ore is composed of crystalline schists and quartz and there is little tendency for the ore to flocculate under the influence of the solutions used. The gold and silver ores of the Western States are in many cases in eruptive rocks; these ores usually flocculate in solution, and in doing so seem to entrap a portion of the value in the solution. At any rate there is a much more noticeable difference in the assays of tank

effluents in the treatment of these ores. This has in some cases been blamed on faulty mixing of the products fed to the tank. In most plants riffles and other devices are put in launders to insure thoroughness in mixing, but our experience in Porcupine would indicate that the ordinary launder makes a perfect mixture. Adsorption, then, would seem to be the more important cause of these differences, and should be a profitable field for further investigation.

Proper precipitation is essential in decantation, as it has always been in every other process, and, as shown by Fig. 6, dissolved gold is lost in proportion to the amount of value in the barren solution used. It will be observed, however, that the loss does not increase as fast as the value of the barren solution does.

It will be observed that the value of the solution leaving T_1 increases at nearly the same rate as the barren solution and that all the preceding overflows increase by exactly the same amount as T_1 . The water dilution cuts the final loss down to a slower increase than the barren solution itself.

Mechanical Features

DORR THICKENER

The mechanics of the decantation system is of the simplest, but is worthy of study none the less. The Dorr thickener is universally used for the separation

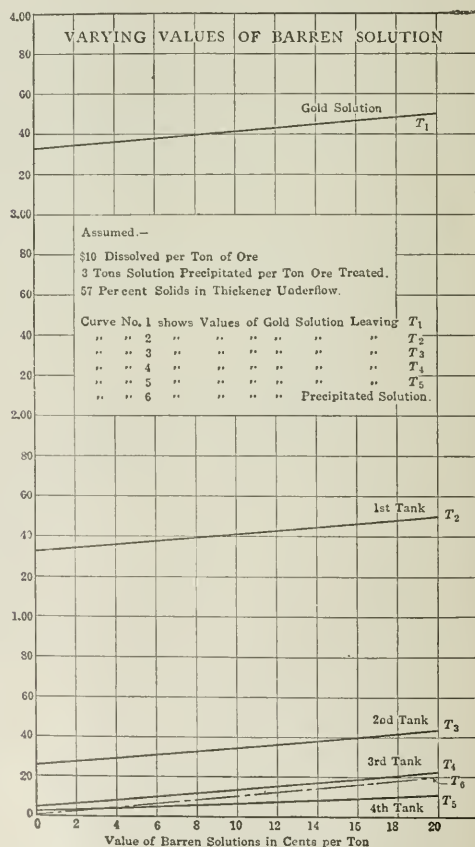


FIG. 6—EFFECT OF VARIATION IN THE VALUE OF BARREN SOLUTION

and is so well known and so standardized that it need only be mentioned in passing. It has been fully described by Mr. Dorr himself in a paper read before the Institute.¹

The arrangement of the tanks in plan may be largely governed by space available and other local conditions. In elevation it is very convenient to have the last tank the highest and the preceding ones successively lower, so that the overflowing solutions may be transferred by gravity with a minimum of attention. Where such an arrangement is not possible, the tanks may all be placed on the same level using automatically regulated air lifts to transfer the solutions from tank to tank.

DIAPHRAGM PUMPS

As a means of transferring pulp, the diaphragm pump has distanced all competitors. The main reasons for this are that it not only pumps but at the same time measures the volume of pulp transferred. The flow of pulp is not easily obstructed by foreign matter, such as chips, waste and the like, since the openings are full pipe size straight through the pump. The capacity of the pump can be controlled with certainty by means of cone pulleys. The attendant's duties are all on one floor, as it is operated from the overflow level instead of at the bottom of the tank. Operating cost is very low on a properly designed pump.

Air lifts were used for a time, owing to their cheapness and simplicity, but they are hard to regulate and are wasteful of power. The most careful watching will not prevent them from "running away," that is, transferring too fast, consequently thinning the pulp and sending large quantities of rich underflow solution toward the discharge. On the other hand, if they are set too slow the gradual thickening of the discharge slows up the flow and finally stops it.

Spigot discharge to a bucket elevator or centrifugal-pump sump has also been tried, pulp and solution being mixed and elevated together. There are several objections to this arrangement, the principal one being high power and maintenance cost for the pumping or elevating machinery. Both the solution and the pulp must be lifted more than the full height of the tank for each decantation. The small high-velocity stream of pulp passing through a spigot at relatively high pressure is subject to frequent stoppages due to foreign matter, and even when this does not cause a complete plugging it interferes with uniformity in operation. There is also the objection that work is done on two floors, one below and one above or near the top of the tanks.

There has been a certain amount of prejudice against diaphragm pumps due to the fact that some of the earlier pumps were poorly designed for the work they had to do. Faulty valves were responsible for much of this. Poor methods of regulation also had their effect.

The practice in most plants in the Porcupine district now is to use cone pulleys for the regulation of capacity, although some of the operators favor regulation by varying the length of stroke.

The valves should be of the floating type, as any hinge device will catch the wood chips that are present in the best-screened pulp. The chips lodged in the hinge of the valve cause leaks which, though small in amount at first, cause cutting of the seat and consequently permanent leakage. With the floating valve there is no place for chips to lodge and the whole circumference of the seat is washed by pulp at every stroke. This type of valve also has the advantage that the lower valve may be placed directly below the upper one and made

small enough to be lifted out through the upper-valve seat when the upper valve has been removed. No tools are required for the removal of these valves and it is a simple matter to inspect them.

The best results have been obtained when the working surface of both the valve and seat were of high-grade rubber. Belting was used at first, but it was found that minute leaks were almost sure to start, due to the fact that belting is not yielding enough to close over any chip that may lodge on the valve seat, and that a leak once started would ruin both valve and seat in the course of a few days. On the other hand, valves of rubber seating on rubber have operated six months without the slightest decrease in efficiency and with scarcely perceptible wear.

Diaphragm pumps have been operated at speeds varying from 15 to 100, the higher speeds usually in conjunction with a short stroke.

The practice at the Hollinger mill has been to use a low speed and a stroke as long as the diaphragm could safely stand. Measurements taken on the Hollinger pumps equipped with standard No. 4 Gould diaphragm at 3-in. stroke gave results as shown in the following table:

Number of Strokes	Volume per Stroke, Cubic Feet	Specific Gravity	Per Cent Solids
14.5	0.139	1.54	54.5
23.0	0.148	1.48	50.5
Tons Solids Pumped per Day	Per Cent Increase in Speed	Per Cent Increase in Volume per Stroke	Per Cent Increase in Tonnage
76.3			
114.5	58.5	6.5	50

From the above figures, which are typical of numbers of tests made, it may be inferred that the volume pumped is roughly proportional to the speed of the pump but that leakage is slightly greater on the lower speeds.

The low speeds and the placing of the discharge lips high enough above the discharge valve to leave 3 or 4 in. of pulp over the valve at the end of the upstroke have rendered the pumps of the Porcupine district practically free from the splash and dirt that have been one of the chief objections to diaphragm pumps in the past.

Where tanks have a settling capacity of over 125 tons of solids per day, it may be found advisable to use two diaphragms in parallel, making a duplex or even a triplex pump. This arrangement has several advantages; with the lowered speed, strains of the pump are lessened and distributed, and repairs can be made on one unit without complete stoppage of the tank discharge. Diaphragm life appears to be roughly proportioned to the number of diaphragms employed, while a corresponding decrease in the strokes per diaphragm does not result in an increased cost for diaphragms.

As a safeguard against waste and other foreign matter it is advisable to screen the pulp before it goes to the decantation tanks, and where small wood chips are to be expected a fairly fine screen, usually of punched plate, will be of great service in protecting thickeners and pumps.

MEASUREMENTS OF SOLUTION PRECIPITATED

Every cyanide plant has some method of determining the amount of solution precipitated, and in decantation plants having only one series of tanks the entire tonnage of precipitated solution is used at one place. If, however, more than one series of tanks are used it becomes important to split this precipitated solution into parts proportional to the tonnage of ore being washed in each series. This can not be done by regulating the valve at the outlet of the barren line, as trial has shown that under some conditions an increase of as much as

¹The Dorr Hydrometallurgical Apparatus, *Trans.*, vol. 49, pp. 211-237 (1914).

50 per cent can be made in the amount flowing from a pipe line without any visible change in the stream.

This difficulty has been overcome by the use of V-notch weir boxes, one for each series of tanks. In each weir box is a float compartment and a float operating an indicator on a scale which reads in tons per 24 hr. While the weir box, which can be readily made at any mine, is not a recording instrument but gives only an instantaneous rate reading, its use greatly simplifies the problem of proper distribution of barren solution. Water also should be added in proper amounts and uniformly distributed. A smaller weir box has been found convenient for this purpose.

It is usual to determine the specific gravities of various pump discharges about a decantation plant at least once a shift. In a small plant this consumes little time but if there is a large number of measurements to be made the distance to be covered by the operator is considerable, especially if he has to return to a central point for each weighing. In such plants, a spring balance with a dial and revolving hand, that can be carried about the plant, is a good type. I have used a milk scale having an adjustable tare-indicating hand, which makes one complete revolution for 10 lb. I use a narrow-necked can which holds just 10 lb. of water when level full. This makes it possible to add a paper dial which can easily be divided so as to read directly specific gravities. The large sample makes possible accurate readings and enables the operator to determine gravity at the place where the sample is taken.

TRAY THICKENERS

In his paper on the Dorr metallurgical apparatus, Mr. Dorr touched on the future of tray thickeners, and spoke of the possibility of a complete decantation plant being installed in one tank. While this has not been done as yet, a four-step decantation followed by a continuous filter is in operation, the four steps of the decantation being completed in two tanks equipped with single trays. While no figures have been made public the results are said to be creditable.

Another use of the tray in decantation, which is shortly to be tried at the Hollinger mill, is to increase the capacity of existing plant rather than to decrease the number of tanks installed. Since the same grade of solution is handled in both tank and tray there is no danger of any mixing of solutions of different grades. This plan should decrease the cost of buildings, tank foundations and building site in almost direct proportion to the increase in capacity gained, while tank cost, power and labor should all be decreased to a marked degree. The outcome of this experiment should have a direct bearing on the future of the decantation process. It must, however, be borne in mind in this connection that some slimes require time for their final thickening and consequently necessitate a tank of some depth, while other slimes find their capacity limit in the thin-pulp settling rate. For this latter class, as explained by Messrs. Coe and Clevenger in their paper on slime settling,² a shallow tank or tray is sufficient while the former class requires a tank of carefully calculated depth to give the required time for thickening.

The Decantation Plant of the Hollinger Co.

The Hollinger decantation plant consists at present of five rows of 40-ft. tanks, four tanks to a row, forming a plant of five units. The tanks are arranged with a difference in elevation of 2 ft. 6 in. between steps with the final tanks of the series the highest, so that all solutions gravitate through and out of the plant to precipi-

tation. The Barrett specification roof is supported on flat trusses, the lower cords of which pass just above the tank rims. These trusses also serve to support the thickener mechanisms as well as the walks between the tanks.

The diaphragm pumps used were designed by the company's staff, and have been very reliable and economical. They are all three-throw or triplex pumps so that in spite of the large tonnage handled the duty on each diaphragm is light. It is not uncommon for diaphragms to last 300 days while the life of the present type of valves and seats has yet to be determined.

The pumps are used not only for pulp transferral, but also for the final discharge. This makes regulation of the final discharge for moisture much easier, more reliable, keeps the work of the operator all on the upper floor and allows the tailing to be discharged at a considerably greater elevation than would otherwise be the case.

The barren solution and water wash added to each row are measured by separate float-reading weir boxes assuring uniform results from the various units.

LABOR

The plant is operated by one man per shift who oils all machinery, watches and adjusts the pumps and records their performance. The solution man makes titrations and regulates the addition of water solution but has no other duties in the decantation plant. A repair man on day shift makes all repairs and has time for other work.

POWER

The power for each tank including motor and line-shaft losses is under 1 hp., while each three-throw pump consumes about the same amount.

COST

The costs for the twelve weeks from Jan. 23, to April 21, 1916, have been taken as typical of what is done by this plant at its present capacity. During this time 85,854 tons were decanted at a cost of \$599 for supplies, including power, and \$1,194 for labor, or \$0.007 per ton for power and supplies, and \$0.0139 for labor, making a total of \$0.0209 per ton for decantation. Labor is no doubt higher here than it will be in the future, as a greatly increased tonnage is to be treated while supplies and power should remain nearly the same. The cost as it stands is about 40 per cent of the cost of filtering on leaf filters at about the same daily tonnage.

EXTRACTION AND RECOVERY

In the ores of the Porcupine district the recovery by dilution seems to be almost the theoretical maximum. Adsorption does not seem to have any appreciable effect. There is a slight dissolving during decantation which, while it adds to the recovery, makes the soluble loss somewhat greater than it would otherwise be.

The figures quoted below on chemical consumption and recovery refer to only two units of the Hollinger plant. The figures on these units are given because the other units of the mill share their feed with the original Moore filter plant, and likewise their barren solution, while for commercial reasons the two units in question have been given a separate solution system and separate precipitation presses. These two units are therefore the only ones upon which all the figures are available.

In comparing the results quoted, however, it should be borne in mind that the flow sheet has been modified in this plant somewhat because of limitations of space, so that the overflow of T_1 instead of that of T_2 goes to precipitation. The effect of this is to raise the theo-

²Laboratory Method for Determining the Capacities of Slime-Settling Tanks, *Bulletin* No. 111, p. 597 (March, 1916).

retical value of the overflow of the last tank 3 cents at 3 to 1 precipitation.

A statement of results follows:

Period covered, same as that for which costs were given—from Jan. 28, 1916, to April 21, 1916.

Tons of ore treated	38,885
Value per ton of ore	\$3.92
Ratio of ore to solution precipitated	100 to 285
Tons solution precipitated	110,604
Strength of cyanide used	0.9 lb. per ton, or 0.0045 per cent
Cyanide added per ton of ore	0.46 lb.
Difference between pulp feed and pulp discharge for first tank after agitators	25 c.
Average moisture in tails	45 per cent
Average value of barren solution	3.2 c.
Dissolved gold per ton of solution discharged	11.71 c.
Dissolved gold per ton of ore discharged	9.57 c.

It is theoretically possible, taking into consideration the flow sheet, the grade of ore treated, the barren solution used and the thickness of pulp attained, to have reduced the overflow of the last tank to 7.6 cents, leaving a difference of 4.1 cents to be accounted for by continued dissolving adsorption, etc.

Viewed in one way it may be said that actual losses are 54 per cent higher than theoretical, but where one is dealing with samples so easily affected by faulty manipulation and where any error except losses in assaying tends to raise the results, a check to 4 cents does not seem bad. The average loss would have been somewhat less if the occasional high results had been omitted, but this was not done.

From the foregoing, I believe one is warranted in concluding that a reasonably accurate forecast can be made of the results to be expected from a decantation plant and that these results may compare very favorably with the results obtained from filter plants.

In conclusion I would say that I am indebted to P. A. Robbins, managing director of The Hollinger Company, for permission to quote results from the Hollinger plant.

Timmins, Ont., Canada.

The Rubber Situation

By Andrew H. King

In a previous paper I outlined the rubber situation as far as this country is concerned. I endeavored to show that we as a people are almost absolutely dependent upon Great Britain for our supply of crude rubber, the utilization of which material goes hand in hand with civilization. If you wish to see what a rubberless community would be like, look on Germany. Her supply is so low that rubber is only used in cases of absolute necessity. Consider her wooden tired motor trucks, and her celluloid nursing nipples. What did the merchant submarine Deutschland take back with her? Gold? No, mostly rubber. It is exactly such a situation that we as a people must guard against.

The proposition is full of pitfalls, even in peace times. The British will certainly be human enough to make us stand their bills for the great war if they can find a means to do so. It has already been suggested by certain unofficial sources that there should be an export duty on rubber. Straws show which way the wind blows, and while nothing really definite has been done, it is evident that they are looking for a way out.

It will be remembered that a few years ago, when Germany first began to put the screws on the potash exportation, that certain enterprising Americans bought in on the ground floor. The matter is now history, but the fact remains that they got out with a brand new lesson in their hats, namely the wisdom of staying away from a foreign monopoly. Several of our rubber companies may have to learn the same lesson, for it is well known that certain plantations in Sumatra and in the Federated Malay States are controlled, if not owned out-

right, by American capital. Considerable weight is given the old saying that blood is thicker than water. These capitalists place great faith in Englishmen, and while I do not wish to injure that faith, I cannot refrain from pointing out the confiscation of German patents by Great Britain. If she will confiscate intellectual property, what may she do to real property in the event of a slight misunderstanding between our respective countries?

There is quite a similarity between the potash and rubber situations. If given time enough it now appears that we will solve the former. The importance of American control has been effectually demonstrated. We must not allow the German monopoly to crush out this infant industry, for should this calamity occur the foundation of our national existence would be weakened, and ultimately a condition might arise when we would learn again that a chain is no stronger than its weakest link.

Fortunately, the rubber problem is not nearly as serious, nor nearly as difficult of attack as that of potash. We have plenty of methods of approach, plenty of skilled minds to call upon, and only lack the necessary capital and incentive. Only a few years ago we saw such an epidemic of wildcat speculation in rubber, and particularly in synthetic rubber, that the general public has been rendered a little leery of rubber investments. However, better times have dawned, and our bankers have learned that there are certain reliable persons called experts who will advise them well. Consequently we have reason to hope for action.

Let us grant for sake of argument that we need an American rubber industry. Let us also grant that we have the necessary capital to go into the matter. How shall we go about it? What avenues lay before us? Shall we pin our hopes to the Guayule shrub, or to any other cousin shrubs which happen to bear rubber? Shall we establish plantations in the Philippine Islands, or in Hawaii? Or shall we resort to the chemist and plunge on synthetic rubber?

In a previous paper I discussed Guayule. The possibility of its revival is very certain. Ever since 1912 considerable shrub-bearing areas have been idle—practically untouched. When the Mexican trouble is over this will mean a large Guayule harvest. At such time a program of conservation must be adopted or the plant will become extinct.

There are other plants acclimated to temperate zone conditions that are worthy of passing mention.

Our common milkweed, *Asclepias Syriaca*, is a rubber producer. It grows abundantly throughout the United States, and is probably better known than any other weed. Its latex, as reported by Fox (*India Rubber World*, 1914, page 645), is thin, milky, and possesses an acid or neutral reaction, besides the characteristic milkweed odor. It may be coagulated by heat or by alcohol. The coagulum is plastic, and when molded into cakes resembles low-grade rubber. The rubber present is of inferior quality, and on the basis of latex represents a yield of only 2 to 3 per cent. The resin contains asclepiadin, which drug finds application in drosy, etc. The rubber might be improved by Spence's sodium process, but the production of anything like commercial quantities would involve so much asclepiadin as to make this otherwise moderately valuable by-product a liability rather than an asset. A point which has been overlooked heretofore is the fact that this weed produces at seed-time a very beautiful, pure white and glossy fiber, which if properly prepared produces a fabric greatly resembling silk. If the production of this fiber were made the principal industry, it might be that the extraction of the rubber from the stalks would furnish a profitable by-product.



FIG. 1—ASCLEPIAS SYRIACA. FLOWERING PLANT OF COMMON MILKWEED

(Photograph by Miss E. M. Kittredge, Spring Valley, N. Y.)



FIG. 2—ASCLEPIAS SYRIACA. FRUITING PLANT OF COMMON MILKWEED

(Photograph by Miss E. M. Kittredge, Spring Valley, N. Y.)

The great *Apocynaceae* family yields a varied series of products, among which are the *Landolphia*, and *Funtumia* rubbers of Africa. It would be expected that the American representative of the family should also be rubber producing. The latex of the well known Indian Hemp or Canadian Hemp (*Apocynum Cannabinum*) contains (Fox, same reference as above) 2.36 per cent rubber—on the weight of latex. This latex is preferably coagulated by acetone, and yields a strong black rubber of very fair quality. The root of this plant yields apocynum, which drug is used in medicine. The bark is strong, fibrous and tough, and was formerly highly valued by the Indians for bow strings. Unless very profitable by-products can be developed from these two plants their value as rubber producers is practically nil.

The Pingue plant, *Actinella Richardsonii* (Fox, *India Rubber World*, 1913, page 467), is related to Guayule, and is found in New Mexico and southern Colorado. It differs from Guayule in that the roots contain the rubber and the tops furnish slips for planting. This plant grows in a deep, sandy soil and the root contains about 7 per cent of a good grade of rubber.

There are many other plants which bear a small quantity of rubber, but to date only Guayule and Pingue have proved profitable.

Chicle contains about 17 per cent of rubber, and has been proposed from time to time as a possible source. This gum belongs to the rubber family, and is secured from the latex of *Achras sapota*. The trees grow in Central and South America, and the latex is secured by very crude methods, which in the advent of a great demand would be liable to permanently destroy the supply. However, scientific methods of tapping could be introduced, and the gum harvested in an economical manner.

But the unfortunate part of this idea is that chicle is already the basis of a very profitable industry, namely, chewing gum, the average retail value of which is about \$30,000,000 per year, in this country alone. The customary 5-cent package weighs about 1 ounce, and contains about $\frac{1}{4}$ ounce of chicle. By a little calculation it is evident that about 600,000,000 packages are sold annually, which represent, say, 10,000,000 lb. of chicle, valued at 60 to 65 cents per pound. On the basis of 25 per cent, this means an annual consumption of about 40,000,000 lb. of chewing gum, the retail value of which is about 75 cents per pound. Since the other ingredients are relatively cheap, the profit on chicle importation must be enormous. In view of the above, any process for the production of rubber using chicle as a base seems to me to be analogous to the substitution of gold for steel in rails. Another point on the subject is that should such a proposition be feasible, we would still be dependent upon a foreign country and upon water transportation, neither of which is considered desirable from a preparedness standpoint.

However, in case of absolute necessity the public can be relied upon to follow up a gigantic salvage campaign, which could furnish us with 1,700,000 lb. of rubber at the bare cost of extraction. Might not this be a good idea for the rubber chemist to investigate even in peace time?

Let us now consider the advisability of establishing plantations in the Philippine Islands. From the very start we must realize that such a procedure would only give us peace time relief, for in the event of war our navy could not be expected to keep the lanes of the sea absolutely free from hostile vessels. At the very best our losses would be considerable. That this is true we have only to consider England's navy, the grandest and mightiest in the world, yet it cannot rid the ocean of

the dreaded "Unterseeboot." An absolute blockade of our ports is rather remote. Unless America should face a coalition of enemies we have nothing to fear. Only Great Britain could make us really uncomfortable. I am thinking now of the time when our great naval and military program will be well under way. At the present writing—but why be pessimistic?

I have reliable information that the greatest drawback which has heretofore prevented capital from planting in the Philippines is the extreme uncertainty of the situation. It has been the obsession of one of our political parties to set these islands adrift—at such time as they seem fit to rule themselves.

Now, is this the right attitude? Let us think of the Philippine Islands one hundred years from now, or the thousand years some people say will be needed before this desideratum is reached. Let us consider that at this time the Filipinos will be capable of self-government. Will they as a people require any more freedom than the people of New Jersey or of Kansas? The desire for freedom and liberty is a natural one, but are the people of these states any less free because of their allegiance to the United States of America? As the Filipinos progress in the study of civil government, will they not appreciate the virtues of a union with the United States?

By all the laws of right and justice the Philippines belong to America. We delivered them from the curse of a decaying empire, saved them from oppression, and paid in gold for their acquisition.

Has the American rule been tyrannical? Have we despoiled their people? Not at all. We have kept order, when necessary, by force of arms. That was our duty, the same as it is the duty of every city police force. We could not permit a state of anarchy to exist such as now exists in Mexico. We abolished an antiquated land system, not by force of arms or by imperial decree, but by some millions of American money paid for friar lands. We sent good American teachers and set up a school system, the working of which has been little short of marvelous. In every way American occupation has been a good thing for the islands. We certainly deserve some gratitude from the Filipinos. We have given them our blood, our money, our brains, and our time. Why should they not appreciate these things, and be content to remain under our flag? The mutual benefits would be very great.

With the Philippines definitely decided as part of the United States, American plantations there would be very good business. On the other hand, should the

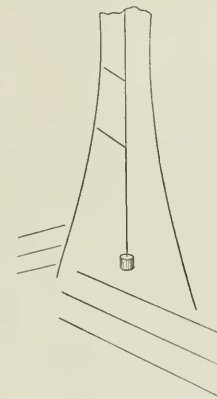
islands be set free there is a possibility of an outbreak of anarchy. Anarchy and business never go together.

It would be well for us now to pay attention to the work of the British planters in the Far East. They have used great skill, patience and foresight. They had to contend with the most adverse conditions, but with characteristic British energy they have created an industry, the magnitude and earning power of which we little appreciate. The establishment of plantation rubber is one of their masterpieces.

In 1877 H. A. Wickham smuggled some 70,000 seeds of *Hevea Brasiliensis* out of Brazil. They were planted in London, and the slips sent on to Ceylon. This was the beginning of an industry that supplied in 1915 about 100,000 tons of crude rubber—68½ per cent of the world's supply.

The major part of the planting has been done in the Federated Malay States, and in Sumatra. To date the capital outlay has been enormous, amounting to about \$320,000,000. In the early days interplanting was resorted to to help carry the load. Tea and coffee found the greatest favor. As the Hevea trees came into bearing these quick crops were gradually discontinued.

The present custom as to planting is as follows: The jungle is cut down and the ground thoroughly drained and cleaned of all old roots, which if left to decay would be liable to cause root disease in the young trees. The seedlings, which have been carefully raised in nurseries under the direction of competent foresters, are set out about 120 to 150 to the acre. As the trees grow they are gradually thinned out until



SKETCH SHOWING
HALF-HERRING BONE
SYSTEM

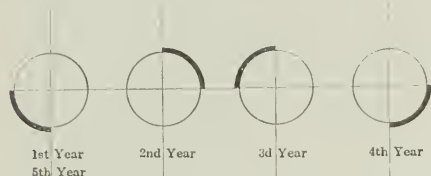
only about 50 to 80 per cent are remaining. This number depends considerably upon the depth of the soil. As would be expected only the poor trees are removed. It is entirely a matter of survival of the fittest. From the time the tree is set out until tapping, which is ordinarily begun in the third or fourth year, about all that is necessary is to keep the plantation weeded, and to turn over the soil around the base of the tree about once a year. It is customary to fertilize with lime and manure, and on poor soils to use a little sulphate of ammonia. Pruning is resorted to when necessary, and all cuts are covered with some preparation to protect the tree from insects.

The tapping problem has received considerable attention. It is quite obvious that maximum ultimate yield per acre is much to be preferred to maximum yield per tree per year. The parts of the tree are: The pitch, wood, cambium, the cortex and the bark. It is necessary to cut through the bark and almost through the cortex, which contains the latex cells. The cambium is a very sensitive membrane, and must not be injured in any way or a wart will form which may kill the tree. The cortex is only about 12 mm. thick, consequently the cuts are of an average depth of only 10 mm. in the cortex.

The half herringbone system of tapping has proved most satisfactory. It was formerly the idea that the more cuts in a tree the greater the yield per tree per year. Unfortunately this did not give the greatest total



yield per acre in the long run. By a long series of experiments the present half herringbone quartering system has been evolved. When first tapped, the tree is laid off into quarters, and in only one quarter are two narrow cuts made, these leading to a central channel. The latex flows down these cuts into the central channel, and down this to an earthenware cup. The tree is tapped nearly every day by removing a very thin shaving of bark and cortex. After a month's time the cuts will have widened only about an inch. By the end of the year they will be together. The next year the operation is repeated on the opposite quarter; the third year cut is made on an adjacent quarter, and that



SKETCH SHOWING QUARTERING SYSTEM

of the fourth on the opposite one to this. By the fifth year, which is the eighth or ninth of the life of the tree, the bark covers the first section and tapping is resumed on the same quarter that was first used. Tapping is really a fine art, and the Malay has proved quite efficient and satisfactory at it.

The latex is carried to the coagulating stations, strained to remove all sticks and other dirt, as well as such lumps of naturally coagulated material as may be present. It is then poured into shallow pans and coagulated by means of acid. Acetic acid finds the greatest use owing to the wide range in permissible concentration to completely precipitate all the rubber. With sulphuric acid this range is only 0.1 to 0.2 per cent, while with acetic the concentration may vary from 0.09 to 0.8 per cent, thus making its use very nearly fool-proof. Other acids can be used such as tartaric, oxalic, formic, etc. Chinese vinegar also sometimes finds application.

After allowing the coagulum to settle, usually over night, the surface scum is removed, the rubber taken out and worked into slabs, which are left with considerable latex inclosed for about six days. This procedure is to give the proteins in the rubber and in the latex an opportunity to decompose into certain undefined substances which give a rapid curing rubber. The work of Eaton and Grantham (the Agricultural Bulletin, Federated Malay States, vol. 3 and 4, various numbers) on the subject of "Variability" has thrown a very great light on the subject of coagulation and the properties of rubber secured under different conditions.

Plantations are at present producing only three important grades, namely: Pale Crepe, Smoked Sheets and Brown Crepe. Pale Crepe is the very finest of their product, and on the largest plantations now amounts to from 70 to 80 per cent of the total output. In some districts it is the custom to add a little sodium sulfite to the latex before coagulating, but this is no longer an absolute necessity, since with care and cleanliness a very satisfactory rubber can be secured without it.

After the slabs have been stored six days they are milled, washed, and hung in a loft to dry for two to three months, following which the thin sheets are ready for packing.

If smoked sheets are to be prepared the rubber is put through the same process as above and the sheets hung in a smokehouse where a slow fire of coconut husks is kept burning. After ten to fifteen days the sheets are

removed and the soot brushed off, when they are ready for packing.

Brown Crepe consists of surface skimmings, natural coagulated lumps, and the better grades of scrap. Some plantations make only Brown Crepe, but these are not many. There are also numerous grades of "scrap," which make up but a very small part of the total output.

The yield from one tree is not large, varying from three to seven pounds, depending upon the age of the tree. Arden (India Rubber Journal, 1916, page 199), states that trees properly cared for will yield about 7 lb. per year when 10 to 12 years old, which, on the basis of 60 trees per acre, amounts to 420 lb. per acre per year. He also estimates the "all in" costs on trees yielding the above amount. He places it at 9.5d., or about 19½¢. per lb. He remarks also that with rubber selling at a shilling a pound (*i. e.*, about 24½¢.) a profit of 2½d. per lb. would be realized, or £4 7s. 6d. (\$21.29) per acre, which would be sufficient to pay a dividend of 10 per cent on an acre capitalized at £43 15s. (\$212.91). Mr. Arden does not fear any speedy drop in the price of crude rubber, but simply gives these figures to show the soundness of the business.

It must not be taken that the trees yield anything near like 420 lb. per acre when first tapped. Taking the average number of trees per acre from the time of planting to the 10th or 12th year as 100, the schedule is approximately as follows:

1st year of tapping.....	70 lb. per acre
2nd year of tapping.....	140 lb. per acre
3rd year of tapping.....	*250 lb. per acre
4th year of tapping.....	325 lb. per acre
5th year of tapping.....	375 lb. per acre
6th year of tapping.....	400 lb. per acre

*This is the maximum yield in some parts of Ceylon.

In spite of war conditions the world's consumption of rubber has increased by 20 to 30 per cent. It is estimated that the Far East has produced in 1916 about 140,000 tons, an increase of 40,000 tons or 40 per cent over the 1915 yield. There is absolutely no such thing as flooding the rubber market. As the quality available increases, the applications multiply and no one can see the end.

To go back to the Philippines, *Hevea Brasiliensis* has been found to grow most satisfactorily in a belt 10 deg. on either side of the equator. This belt includes the Philippine province of Moro, whose most northern point is about 9 deg. north latitude. This district includes the island of Mindanao, its tributary island Basilan, and other smaller islands. It is a truly tropical region, and very well adapted to planting. The soil is equal in every way to that of the best rubber-growing district in the world. The rainfall is about 100 in. annually, and is evenly distributed. The temperature rarely exceeds 92 deg. Fahr., and what is more important the province lies outside of the typhoon belt. This is a distinct advantage, since storms often wreak great havoc in Ceylon, Sumatra, and others of the British possessions in the Far East.

There have been small experimental plantations started in this district. About 6000 acres are now under cultivation. The planting averages about 90 per cent Hevea, and 10 per cent Castilloa. Some Ceara has also been planted, but it was found to be unsatisfactory.

The Agricultural Department of the Moro province has published the following figures, which show the relative costs of bringing new land under cultivation in the island of Mindanao, and in various other islands of the Far East.

Moro	\$50.94 per acre
Sumatra	73.60 per acre
Java	109.94 per acre
Federated Malay States.....	137.42 per acre

The relative costs of upkeep are given as follows:

Moro	\$18.00 per acre
Sumatra	20.00 per acre
Java	23.00 per acre
Federated Malay States	29.00 per acre

Taking all in all, it is estimated that an acre of land may be prepared, planted, and brought to bearing in the fifth year for \$150.

The labor situation is good, the average Malay is quite intelligent, and shows evidence of a one-time civilization of no mean sort. The stories of the ancient Malay empire may not be as mythical as is commonly supposed, but laying all that aside he can be trained to perform the most skillful operations, and the tapping of rubber trees is but one of these. He is reasonably industrious, and if properly handled proves quite satisfactory. The daily wage prevailing ranges from 20 to 30 cents. If anything be needed to make the proposition more lucrative, it is found in the large tracts of government land which can be secured quite reasonably.

Besides the island of Mindanao, the island of Mindoro has also been the scene of considerable experimental planting, with a fair degree of success notwithstanding the fact that it lays at about 13 deg. North latitude. Experiments in the Philippines have languished for want of capital. There are great possibilities there, and what is most needed is for the American people to get behind the proposition and push.

Some experiments have also been made in the Hawaiian Islands. Up to 1913, the date last reported, about 1500 acres were planted in rubber. Of this area about 300 acres are planted in Hevea, and 1200 in Ceara. (*Manihot Glaziovii*.) The latter has been found to be most satisfactory in this region, notwithstanding the fact that the tree drops its leaves annually and must therefore be left alone from February to May.

The soil is porous, the rainfall about 100 to 200 in. per year. The planting has been done in the Nakiku district of the island of Maui, and in the Puria district of the island of Hawaii. A fair degree of rubber has been produced, but considering everything it is the writer's opinion that the place for American plantations is the Philippines rather than Hawaii.

It has been my aim to present the possibilities of an American crude rubber business. To my mind we must resort to Guayule if we would produce rubber in any quantity within our borders. This step is absolutely necessary as a preparedness measure. Moreover, there is money in it. Experiments along this line are now almost completed, and in the very near future we can expect cultivated Guayule to take its place among commercial rubbers.

A plantation industry in the Philippines would be entirely a good business proposition, if certain parties would quit playing schoolboy politics and recognize the economic needs of the nation.

At this time there is strong talk in England and in France of replacing the embargo on crude rubber exports. The claim has been made that the Rubber Club of America has failed to live up to its agreement in allowing the submarine Deutschland to obtain two cargoes of rubber from this country. This agreement has to do only with rubber obtained from British and French possessions, and the Deutschland's first cargo is reported to have been obtained by certain parties in the open market. Very probably some British rubber made up that cargo, but by that act those parties are forever barred from further purchases, and have brought upon themselves the ostracism of every American rubber man. The second cargo was obtained from the Dutch East Indies, and the British Government has nothing whatever

to say in the matter. The Rubber Club of America has lived up its agreement to the very best of its ability, but having no police power it cannot prevent occasional infractions of the rules. It can and does say that such parties as break the rules once can never do so again.

The possibility of the restoration of the embargo makes me as an American wish to go them one better, and grow our own rubber.

The subject of synthetic rubber will be taken up in a subsequent paper.

Training the Works Chemist

By Frank E. Lathe,

Chief Chemist, Granby Cons. Mining, Smelting & Power Co., Ltd

I well remember my surprise, when, on securing a position as chemist shortly after graduating, I learned that I would be expected to do each morning in about two hours, work that would have taken me more nearly two weeks in the college laboratory. Probably many another college man has had a similar experience, even leading him to question the practical value of his training. However, I think, it will be generally conceded that the chief value of technical training lies, not in the precise methods taught, but rather in the fundamental principles of chemistry on which all methods must be based, and on a general familiarity with the various operations to be performed. But the fact that theory is more important to the college man than practice is a poor reason for not teaching the student to make the most of his laboratory periods, and a little applied common sense—scientific management, for those who prefer the phrase—will not only fit him better for the practice which will eventually become his daily work, but will also enable him to accomplish far more in the limited hours to be devoted to practical work at college.

Many teachers of analytical chemistry have had no experience in work of this kind under commercial conditions. They may owe their appointment to their ability to make very accurate analyses, or to the fact that they were capable research chemists. If so they are scarcely to be blamed for worshipping the god of accuracy and shunning the demon of speed—but how often the furnaceman requires to know in a few minutes the approximate sulphur content of his steel, or the grade of his copper matte, while accurate results given him the next day would be worthless! In practical work accuracy must frequently be sacrificed to speed, and while some of the quick methods are already taught in our colleges I want to enter a plea for more instructors who have made good under actual working conditions, and who will therefore direct the energies of their students along the most practical lines. In the case of mining and metallurgical students this may often be accomplished by placing all quantitative analysis under the complete control of the metallurgical department.

I will now indicate some of the points which I believe might well receive greater emphasis in the training of the chemist:

First, the acquirement of habits of thoroughgoing cleanliness and systematic procedure. I see held up in horror the hands of many a man who has for years taught—by example if not by precept—that a little of dirty beakers, retorts, test tubes, etc., is necessary to create a proper "atmosphere" for work. But of the men whom I have observed in practice the most efficient were those whose work was reduced to a system, who kept every reagent bottle and piece of apparatus clean and in its appointed place, and who consequently performed their work quickly and well. Surely cleanliness and order are two of the most important factors in the

achievement of analytical success, and the first day of instruction in practical chemistry is not too soon to begin training along these lines.

Second, a general survey of the work to be done by each student during the college year, and the drawing up of a systematic plan of operations; a study of the different determinations, with a view to running several at one time, in order that every moment may be fully occupied.

Third, not only the most accurate methods required in practice, but, even to a greater extent, the quick methods. The student should know the error permissible in such work, and should govern his weighing, filtration, etc., accordingly. Many a college graduate required to determine the iron in a slag, with an error limit of one part in 100, will weigh his sample to one part in 5000, and actually spend longer in the weighing than a practical chemist would require for the determination. This is on a par with reporting to hundredths of a per cent results not closer than one per cent to the correct value.

Fourth, the helps to rapid work. These consist of both mechanical devices and a knowledge of conditions favorable to the performance of the various operations. College laboratories spend much for expensive apparatus which is seldom used, while but a small sum would be required to provide the students with numerous devices which would greatly facilitate rapid work, and which are to be found in most works laboratories. Descriptions of many such are to be found in the technical publications.

As an example of the desirability of studying conditions I will mention three helps to rapid filtration which were not sufficiently impressed upon me at college: hot precipitation, with subsequent boiling; the use of the suction pump for some precipitates, and its avoidance for others; the selection of the proper filter-papers for various precipitates and conditions.

Fifth, the development of the student's judgment, when he has gained some degree of familiarity with analytical methods. Though required to make analyses for definite elements or radicals, he should be allowed considerable liberty as to the choice of method. This choice is extremely important, being influenced by the degree of accuracy required, the time allowed for the determination, the modifications to be made in the presence of interfering elements, or by the fact that several determinations are to be made in the same portion.

To illustrate this point, the electrolytic method for copper is rightly valued for its accuracy, but as described in a leading text-book the presence of lead, ar-

senic and bismuth is assumed. The chemist who would deliberately choose that method, as described, in the known presence of these elements, is in dire need of instruction in the choice of method.

Something like the following might be used as a guide in the determination of copper:

(A) For accurate work.

(1) When ores do not contain interfering elements, electrolytic.

(2) In presence of As, Bi, etc., iodide.

(B) For approximate work.

(1) Ores, slags or tailings under 1.0 per cent Cu, colorimetric.

(2) Mattes, cyanide.

(3) Medium or high grade ores.

(a) No Zn, etc., cyanide.

(b) Zn, As, etc., present, shortened iodide or permanganate.

(c) If no interfering elements, electrolytic, as little manipulation is necessary.

Sixth, the value of considerable familiarity with such determinations as those of silica, sulphur and the common metals (both accurate and approximate methods) rather than a single determination of a very long list of elements. The chemist who can determine a few elements well should be able, with the assistance of a good text-book, to get satisfactory results for any. The intensive training will make a deeper mental impression and produce a greater self-confidence than the extensive. At present the young graduate is likely to think that he has been taught the best method for each element, but he may find that his method is far from the best under the practical conditions which confront him.

PRACTICAL APPLICATION OF THE ABOVE SUGGESTIONS

No cast-iron rules can be laid down as to which methods or procedure should be followed in works laboratories. In each plant the chemist must be governed by local conditions in all that he does. For this reason, if for no other, the example which I will give of how the principles enunciated above have been applied in the laboratory of one copper smelter is not intended to be taken in any sense as a model, but simply as an illustration. And it is probable that another series of chemists might have differently arranged the same work to secure equal or greater efficiency. Of the succeeding chemists who have contributed towards the goal of greatest speed with all the accuracy necessary I wish to give especial credit to George M. Lee.

Determinations and accuracy required: Cu on sixteen samples of blast furnace slag to 0.02 per cent; SiO_2 , Fe and CaO on an average of the same to 0.2 per cent; SiO_2 (insol.) to 0.5 per cent and Cu to 0.1 per cent on each of nine samples of converter slag; Cu to 0.5 per cent on sixteen samples of matte.

Plan of work: Errors will be allowed in weighings, but in no case must these exceed one-fifth the permissible error in result. Cu in blast furnace slags, running about 0.20 per cent, will be estimated by color, in converter slags (1-2 per cent), and mattes it will be determined by the cyanide method. Only one evaporation is required for SiO_2 ; the result on the blast slag will be about 0.6 per cent lower than the true SiO_2 , those on converter slags a little high, due to imperfect decomposition. Fe will be by the bichromate method—the permanganate would be equally good—CaO by the permanganate. The SiO_2 and CaO are the longest determinations, so will be started first and given closest attention. All the others are fairly short. Only sixteen cyanide burettes are available, so mattes and converter slags will be run separately for Cu.

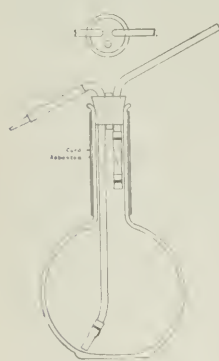


Fig. 2 Wash Bottle



Fig. 1 Sprinker
Made of tin or lead



Fig. 3 SnCl_4 Bottle
To use, invert

For wash bottle, bore three holes in rubber stopper, as shown, using wet borer and starting holes at small end. For valve, tie rubber tubing securely to lower end of mouthpiece, fold over loose end and tie tightly. Cut two quarter-inch vertical slits on opposite sides—one is shown. Tubing in bottom allows emptying bottle without blowing air over. Wrap neck with wet sheet asbestos, covering with layer of heavy cord, drawn tightly. To use, place thumb over open tubing, blow, then remove thumb to release pressure. Constant blowing not necessary.

Mechanical equipment: (That which is in common use in all laboratories will not be mentioned.) Sufficient three-heat electric hot plates to accommodate all the work at once. Overhead heater for water, with bottom outlet, rubber tube and glass tip for washing precipitates. Overhead tank for cold water, with siphon outlet and $\frac{3}{8}$ -in. rubber tube terminating in sprinkler device (Fig. 1) for making quick dilutions in casseroles and beakers without spilling liquids in latter. Overhead ammonia bottle with siphon, and rubber tube reinforced with friction tape. Special wash bottle (Fig. 2), with valve to prevent hot water or acid fumes getting into mouth of operator and to keep up pressure without continuous blowing. Special bottle (Fig. 3) for the addition of SnCl_4 in small quantities. Cyanide burettes without pinchcocks, but with rubber tubing containing glass beads as valves, and glass tips. Siphons for filling burettes from elevated bottles or carboys. Titration plate of paraffin and zinc oxide—cleaned, when necessary, with gasoline. Shaving-stick box with small holes punched in top, containing crystals of $\text{K}_2\text{FeC}_2\text{N}_6$ for making up small amounts of solution for Fe titration. Dropping bottle, painted black, for the preservation of easily decomposable "slag acid" (see below), and for the addition of small quantities of it when surplus acid has to be evaporated— SiO_2 determinations. Wooden tray to hold eighteen 400-c.c. beakers or equivalent. Enamelled saucers, in place of sample envelopes, for matte and slag samples, each bearing pasted label showing number of furnace or converter and shift to which sample belongs.

Routine of operations: Place on tray ten 3-in. casseroles, with watchglass covers, one 250-c.c. beaker, and nine 400-c.c. beakers. Out of each blast furnace slag sample take small spoonful of slag, mixing well together on rolling cloth. Weigh out of this average 0.5 gm. (within 0.001 gm.) into 250-c.c. beaker for Fe and 0.5 gm. (within 0.0005 gm.) into casserole for SiO_2 . Weigh 0.5 gm. (within 0.002 gm.) of each of converter slags into casseroles for SiO_2 , and 2.0 gm. (within 0.01 gm.) of same into 400-c.c. beakers for Cu. From dropping-bottle add to each casserole 1-2 c.c. "slag acid" (mixture of four vols. HNO_3 , one vol. HCl , two vols. H_2O), cover and set on plate at high heat. Into each 400-c.c. beaker pour 10-12 c.c. HNO_3 , and set on plate at medium heat without covers. From wash bottle pour 5 c.c. boiling H_2O into 250-c.c. beaker, and while rotating beaker on hot plate add slowly about 5 c.c. HCl . With glass rod loosen any SiO_2 from bottom and heat one minute longer. Remove, add three drops SnCl_4 , dilute to 100 c.c. with cold water, add 25 c.c. saturated HgCl_2 solution. Let down solutions in all burettes to zero. Place beaker of saturated oxalic acid solution on asbestos on plate. Partly remove covers from casseroles, now almost dry. Shake a few crystals $\text{K}_2\text{FeC}_2\text{N}_6$ into beaker, add 25 c.c. H_2O , transfer to dropping-bottle, put dozen drops on spot plate. Titrate Fe—solution reading directly in percentage. Put eighteen colorimetric bottles under funnels and fold a 15-cm. S. & S. No. 595 filter paper into each funnel, afterwards moistening. Remove dry casseroles from plate. To each 400-c.c. beaker on plate add from sprinkler 20-30 c.c. cold water (making cool enough to handle with bare hands), remove, dilute similarly to 200 c.c., add 10-12 c.c. NH_4OH (from siphon), stir with rubber-tipped glass rods (using both hands), place under KCN burettes, add 1.0 c.c. to each, again stir. Pulverize well the dry residues in casseroles, replace on plate. Make second addition of KCN—in amount according to depth of color. On tray place eighteen $3\frac{1}{2}$ -in. casseroles, into each weigh 1.0 gm. (within 0.01 gm.) furnace slag, including as standards two previously determined by

electrolysis to contain 0.19 and 0.21 per cent Cu. To each add 10 c.c. HCl and set on plate at medium heat. Remove silica casseroles. Make third addition of KCN (little will be required). On tray place sixteen 400-c.c. beakers and into each weigh 0.5 gm. matte (within 0.001 gm.). To each color copper casserole add 2-3 c.c. HNO_3 , turn heat off plate. To each matte beaker add 10 c.c. HNO_3 , and set on plate at medium heat. To each SiO_2 -casserole add 10 c.c. HCl , leaving off plate. Make final addition of KCN, if any required, read burettes, adjust to zero. Attach filter pump, fold carefully ten 11 cm. No. 1F Munkell's filter papers. To each SiO_2 -casserole add 25 c.c. H_2O , set on plate at high heat. Dilute colorimetric determinations to 100 c.c. each, stir with rubber-tipped glass rod (use same for all), loosening well from bottom. Slightly dilute mattes (to cool), remove from plate, dilute to 200 c.c. To each colorimetric casserole and matte beaker add NH_4OH to precipitate Fe and 5 c.c. additional. Stir all well. Place matte beakers under burettes. Filter silicas by suction, washing each once with HCl from dropping bottle or wash bottle and three times with hot H_2O . Place silicas in annealing cups. Transfer first filtrate (from blast furnace slag) to 400-c.c. beaker, retain others in suction flask. To first add NH_4OH till alkaline and 5 c.c. additional. Place on plate at high heat. Place annealing cups in front of muffle—just below red heat. To each matte beaker add KCN, stirring constantly, till the color changes to light brown. Pour hot oxalic acid solution into boiling filtrate from SiO_2 till CaO is precipitated as oxalate. If very little acid be required, either add 1.0 gm. ammonium oxalate or reprecipitate Fe with NH_4OH and redissolve in oxalic acid. Move annealing cups to hottest part of muffle. Make second addition of KCN to mattes, according to color. Filter slags for Cu into colorimetric bottles, washing precipitates twice. Make third addition of KCN. Filter CaO through 12.5 cm. Munkell's No. 1F paper, washing nine times at intervals. Put 100 c.c. H_2O and 10 c.c. H_2SO_4 in original 400-c.c. beaker and set on hot plate. Fill colorimetric bottles to mark and shake. Remove annealing cups from furnace. Compare Cu in slags with standards. Make last addition of KCN to mattes (if any necessary) and read burettes. Drop filter containing calcium oxalate into boiling H_2SO_4 solution and titrate at once with KMnO_4 . Weigh silicas.

An hour and a half is good working time for one chemist on the above, though it has been done occasionally in an hour and a quarter. While this is not as fast work as done by many chemists running determinations of one kind only, it may be sufficiently in advance of that of the student to illustrate the point that I wish to emphasize—that by the adoption of quick methods, the use of convenient equipment, the concurrent determination of several elements or radicles, and a careful planning of all work, it is possible to accomplish considerable even in a time as short as one of the college laboratory periods.

In conclusion, I will state my belief that one year's practical experience before or during his college course will give the average man a new sense of the opportunity which is his during his student life, and the growing insistence of instructors upon such practical work is one of the encouraging signs of progress in the training of technical men.

Grand Forks, B. C.

Government Radium Tests.—In October, 1916, the United States Bureau of Mines received the largest quantity of radium to be tested for a single month. The total value of the radium was \$77,000. Up to date the aggregate value of radium tested by the bureau is above \$1,000,000.

Synopsis of Recent Metallurgical and Chemical Literature

Metallography

Grain Growth Phenomena in Metals.—In a paper to be read before the members of the American Institute of Mining Engineers, at the February, 1917, meeting of this society, at New York, ZAY JEFFRIES discusses factors influencing fast growth phenomena, fast growth phenomena in low-carbon steel, and effect of cold deformation on uniformity of orientation of original grains.

Under the first heading come the effect of rate of heating, the resistance to grain growth, influence of grain size prior to deformation temperature and deformation gradients, and the influence of the thickness of the sample. The conclusions drawn on the effect of the rate of heating are: The time factor is always a governing factor in the first stage of grain-growth; if the time of heating is short, the germinative temperature is raised. The formation of large grains in metals may occur at relatively high temperatures when the rate of heating is rapid.

The resistance to grain growth is divided in two parts: First, the resistance offered by the pure predominating constituent and second, the resistance offered by impurities. At the germinative temperature the present of impurities favors the formation of coarse grains. As the resistance to grain growth increases, the germinative temperature increases and the time necessary to form large grains decreases rapidly. As a general rule, other conditions being equal, the finer the existing grains at the germinative temperature, the greater will be the tendency toward selective grain growth.

In a pure metal with a given amount of cold deformation, the grain size before deformation will have a marked effect on the selective grain growth during annealing. If the initial grain size is large the grain fragments formed during annealing will also be large and vice versa. If the grains are initially large the fast growth phenomena may be almost completely masked. The formation of large grains at the germinative temperature is dependent upon the evenness of the grain size with a temperature gradient or an even temperature with a deformation gradient or any combination of the two. The difference in temperature of recrystallization furnishes the cause for selective grain growth due to deformation gradients. When the total average cold deformation exceeds about 30 or 40% reduction in area of the metal, the number of germinative grains formed during normal muffle heating may approximately equal the number of equilibrium grains for the maximum temperature reached during annealing. The effect of thickness of section on grain growth in metals is general. In wires of small diameter the author has found two regions in which fast grain growth takes place. One occurs at the germinative temperature and the other occurs at most any temperature above that, the time varying inversely as the temperature. At the second temperature the large grains form invariably near the surface of the sample. The formation of large grains in wires of small diameter may be invariably checked by the introduction of impurities, such as non-metals. The introduction of impurities has the same effect as lessening the diameter of the wire.

The author then applies the above mentioned facts to the theory of grain growth in low-carbon steels. Here, he states, that the formation of gases in metals are also to be considered as offering resistance to grain growth. This is due to the fact that gases in solution

or mechanically entrapped affect the annealing temperature after cold deformation, as Rose and Phelps have demonstrated.

According to Prof. Howe, the uniformity of orientation after cold deformation is greater within the individual original grains than between adjacent grains. This, Jeffries claims, is true for the majority of the cases, but it also must be considered, that in cold-deformed metals there is sufficient difference in orientation within the original grains to be the chief cause of recrystallization on annealing. That this may generally be observed is due to, first, that the diameter of the individual grains in which we can study etching pits is usually not more than 0.0002 in. and, therefore, any difference in orientation of the grains is not readily visible; and secondly, the sections which are usually examined in deformed metals are the most conducive to similar etching tints.

Lead

Matte Granulation at Herculaneum, Mo.—S. PAUL LINDAU and HENRY B. SMITH will present a paper under the above title at the February, 1917, meeting of the American Institute of Mining Engineers at New York. The St. Joseph Lead Co., at Herculaneum, Mo., have decided to granulate the matte obtained at that smelter in order to eliminate a large amount of labor and save the crushing.

The matte is tapped into 6 cu. ft. iron ladles. These are transported to the granulating plant by electrically driven overhead cranes. The matte is received in a cylindrical container, which in reality is a specially devised Traylor converter without the tuyeres and has a 20 in. opening at one end for the flue and oil burners. It may be tilted and is lined with a 9-in. lining of magnesite brick. The consumption of 18° to 20° Be. crude oil is 250 gal. per 24 hr. or 2 to 2½ gal. of oil per ton of matte granulated. Thirty lb. of air are supplied per burner for atomizing the oil.

The liquid matte is granulated by pouring it through two superimposed flat jets of water shooting horizontally into a concrete tank lined with cast-iron plates. The stream of matte is accurately directed on to the jets of water by means of a pouring box. This box is lined with common brick and the matte is poured into it by revolving the container. A dewatering drag conveyor removes the granulated matte from the tank, the floor of the latter sloping at an angle of 30° towards the trough in which the conveyor operates. The conveyor elevates the matte over the slag track and discharges into railroad cars, which are weighed, the contents sampled and dumped into roaster bins. A V-shaped settling box takes the overflow of the tank proper and saves the coarser slimes, while the fine slimes are collected in a series of settling tanks. An excelsior filter finally cleans the water from the end settler, which then goes to the circulating pond. Two series of settling tanks are used, one lying idle while the other is in operation.

Under the old regime the cost of matte handling including screening, was \$1.43 per ton. Granulation costs only \$0.75 per ton, thus giving a saving of \$0.68 per ton of matte granulated. The following two tables will be of interest:

Summary

Matte granulated per 24 hr., tons.....	100
Rate of pouring, cubic feet per minute.....	3.2
Oil consumed per 24 hr., gallons.....	250
Oil per ton of matte granulated, gallons.....	2.5
Water used per minute (under head of 40 ft.), gallons.....	100

Screen Analysis on Granulated Matte

Inch-Mesh	Per Cent.
On 1.....	5
On 3/16.....	4
On 1/8.....	14
On 1/16.....	35
Through 1/16.....	42

Pitch

Coal Tar Pitch.—*The Iron and Coal Trades Review* (London) gives the following information on pitch taken from a circular sent out by the London Coke Committee: "The prevailing condition of scarcity and high cost of steam coal naturally direct attention to the fuel value of the huge accumulations of pitch which now tend to encumber the working up of high-explosive munitions of war at coke oven, gas works and other tar distilleries. The total yearly production of pitch at the 248 tar works registered in 1915 has been estimated at over 1,000,000 tons. With the sudden closing of the Continental market in August, 1914, and the continued restrictions on export trade, hitherto the chief method of disposal, the outlook for pitch and, incidentally, coal tar in the near future is extremely problematical. Prospective new outlets for use in gas and briquette making have not yet materialized to any appreciable extent, and with the increasing demand for coal tar derivatives which may be confidently anticipated, the possibilities of the fuel field as an outlet for surplus pitch should be critically examined. Considered as a fuel for steam boiler and other furnaces, pitch has distinctly attractive features. Not only is its calorific value—viz., 15,000 to 15,500 B.t.u. per pound—higher than that of the best quality Welsh steam coal, but its present price in the Midlands and London district respectively is only about one-third to one-half that of such coal; moreover, it is practically pure carbon, and ash and moisture free, so that in whatever proportion it may be added to other staple fuels, more than an equivalent amount of such fuel may be released for sale or export. The relatively high price realized for pitch has in the past naturally precluded its direct use as fuel. Experience in and special appliances of proved utility for its use directly as fuel are therefore lacking, or at least unknown to the would-be user. Recent experiments in this direction which have had for their object the provision of a simple and inexpensive appliance in the form of a specially designed firebar are therefore of some interest. The chief difficulty experienced in attempting to burn pitch has been the low fusing and volatilizing temperature common to all pitches and the consequent tendency to separate carbon in the form of dense smoke. Compared with average bituminous coal containing 23 per cent volatile matter, pitch contains about 55 per cent, the remainder being practically pure amorphous carbon. The claim is made that by means of this special firebar, coal tar pitch may be consumed in conjunction with coke with considerably less than the ordinary amount of smoke observed at the chimney of a coal-fired boiler. The *modus operandi*, which has been tried with some success in certain gas works boilers, is to substitute a number of "pitch" bars for an equivalent number of existing firebars in a boiler furnace fitted with steam-jet, forced-draft apparatus of ordinary construction. Pitch, broken to any convenient size, is fed on to the pitch bars, where the heat of the surrounding fire causes it to collect and volatilize; the rate of such volatilization being controllable by means of the special formation of the pitch bars within limits which insure practically smokeless combustion. The partially coked residue remaining after the more volatile constituents have been burned off is periodically raked onto the rear portion of grate, where its combustion is completed.

Large Sugar Beet Crop in 1916.—Preliminary returns from the beet-sugar factories indicated a production of 918,000 short tons of sugar during the 1916 campaign. The area harvested was 680,000 acres. The sugar production exceeds the highest preceding crop in 1915 by 44,600 tons.

Recent Metallurgical and Chemical Patents

Caustic Soda

Manufacture of Caustic Alkali.—A patent has been granted to EDGAR A. ASHCROFT of London, England, on a process of producing anhydrous caustic alkali by treating fused alkali metal (produced in an electrolytic cell from an alkali salt in a fused state) with ammonia in one cell to produce an amid. The amid is run into a second cell and heated with steam, producing anhydrous caustic alkali and free ammonia. The product from the second cell is run into a third cell into which the free ammonia from the second cell and steam are passed, where the reaction is completed and the ammonia dried. The dried ammonia is returned to the first cell for use again. (1,198,987, Sept. 19, 1916.)

Phosphoric Acid

Electric Furnace for Phosphoric Acid.—Improvements in an electric furnace for producing phosphorus and phosphoric acid vapors from phosphate rock are patented by INGENUIN HECHENBLEIKNER of Charlotte, N. C. (assigned to Southern Electrochemical Company). The furnace is adapted to produce phosphoric acid from a mixture of phosphate rock, siliceous material and carbon, the gases consisting of phosphorous vapor, carbon monoxide and phosphoric acid. The improvements consist in using the gases to preheat the charge and in improved cooling devices. (1,202,837, Oct. 31, 1916.)

Tungsten

Metallic Tungsten.—An electrolytic method of producing metallic tungsten has been patented by FREDERICK G. KEYES and ROBERT B. BROWNLEE of East Orange, N. J., and assigned to the Cooper Hewitt Electric Company. In this process tungsten trioxide is subjected to a temperature of 2000 deg. C., in an electrolytic bath with a rotating tungsten cathode and an anode of sintered tungsten. The electrolysis produces a lower oxide of less resistance, permitting the passage of the current readily. The crucible is of tungsten or of noncontaminating material. (1,202,534-5, Oct. 24, 1916.)

Tin

Electrolytic Recovery of Tin.—A patent has been issued to ALBERT E. BATTLE of Aldgate, London, England, on the electrolysis of tin and its salts. The process is applicable to the production of tin from ores or the recovery of tin from tinplate. The electrolyte consists of tin or a salt of tin such as the sulphate or protochloride dissolved in ortho phosphoric acid, either concentrated or dilute. The tin ore or scrap is used as the anode in this solution. For a good deposit of tin the patent states that 50 grams per liter of tin salt dissolved in 10 per cent phosphoric acid will be satisfactory. (1,202,149, Oct. 24, 1916.)

Cellulose

Electrical Treatment of Cellulose.—In a patent of ALBERT L. C. NODON of Bordeaux, France, it is proposed to treat wood or other forms of cellulose electrically in order to preserve them and increase their strength by first immersing for a short time in a solution of zinc chloride, sodium chloride or other conducting salts, and then subjecting to an alternating current of low frequency. The process is applicable to wood, textile plants, artificial silk, fabrics, paper paste, paper, etc. (1,198,867, Sept. 19, 1916.)

Electric Furnaces

Improvements in Birkeland-Eyde Furnace.—A new method of introducing and withdrawing the gas in a

Birkeland-Eyde nitrogen-fixation furnace, which is claimed to increase the output is patented by CARL O. A. DÖVLE of Notodden, Norway, and assigned to the Norsk Hydroelektrisk Kvaelfstofaktieselskab, of Christiania, Norway. In general the gases have been conducted through electric arc furnaces of the flame disk type along the whole flame surface, either introducing the gases at the center and withdrawing them at the periphery or vice versa. The present patent proposes to conduct the gases over only a small portion of the flame, as shown by the illustration Fig. 1 in which A represents the furnace, B the flame disk, C the inlet openings and D the outlet openings for the gases. A cooling coil shown at E may be used to augment the cooling effect (1,194,606, Aug. 15, 1916) in case it is desired.

Electric Arc Furnace.—According to a patent of EMIL EDWIN of Christiania, Norway, (assigned to the Norsk Hydroelektrisk Kvaelfstofaktieselskab) greater

stability can be produced in flame arc nitrogen furnaces of the Schönherr type, if no ground connections are made. The long stable arcs in electric furnaces of the Schönherr type are generally maintained between an insulated electrode and a cooled tube, which is connected directly to the flame tube and the outer parts of the furnace. Fig. 2 shows a drawing of three furnaces so arranged. The insulated electrodes are shown at D connected to a three-phase system, and the furnaces are represented by A, B and C. The flame is maintained between the lower electrodes and the interior wall of the coolers H. Previously these coolers and the flame tube were grounded. According to the present invention they are connected together by connectors I as shown but are insulated from the ground. It is claimed that this arrangement gives a better stability of the arcs. (1,193,882, Aug. 8, 1916.)

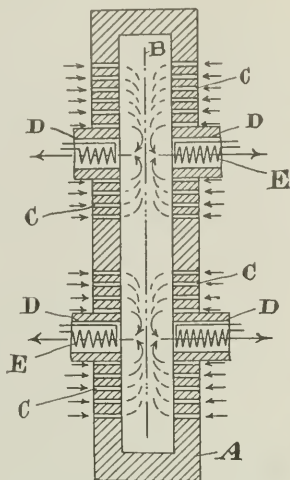


FIG. 1—ELECTRIC FURNACE FOR PRODUCING NITRIC ACID FROM AIR

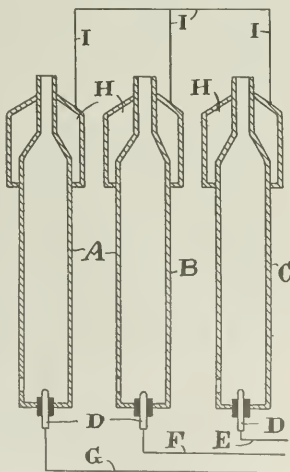


FIG. 2—THREE-PHASE ARC FURNACE SYSTEM

Constant-Current Closed-Circuit Arc Welding System

Present arc welding practice is based on operation of arcs from constant-potential circuits, and since arcs operated under these conditions are unstable, it is necessary to use in series with each arc a ballast resistance.

In the early days, comparatively high-voltage circuits were used and enormous quantities of energy wasted in resistance. Later, as arc welding became of greater industrial importance, generators were constructed especially for the purpose, and the voltage was made as low as possible, until finally it has settled down to from 60 to 70 volts. Automatically controlled resistance which changes with the value of the current, permits the use of a lower voltage, but the arc still has the constant-potential characteristics.

A normal welding arc consumes about 22 volts. However, depending upon the operator and upon the work, it may vary from 18 to 28. Therefore, any voltage pro-



FIG. 1—SELF-REGULATING WELDING GENERATOR

duced by the generator in excess of this must be absorbed in resistance and wasted.

The constant-potential arc when operated in multiple with other arcs, requires a separate circuit from the generator end of the line, or at least from a point in the distribution system where the voltage regulation is close, otherwise the coming on and the going off of the various arcs will disturb the regulation to an intolerable degree.

On account of the expense of low-voltage distribution circuits for constant-potential arcs, practice has drifted toward the single-arc unit, portably mounted.

The Electric Welding Company electric welding contractors who have been in electric welding business for nearly ten years, developed in their practice a new system of arc welding, and in order to place this system on the market, organized the Arc Welding Machine Company as a separate corporation. The Arc Welding Machine Company has perfected the system now known as the constant-current closed-circuit system, which operates arcs in series.

This method has all the advantages of series distribution, namely, the size of wire is uniform throughout the system and carries a uniform current, independent of the length of the circuit as well as of the number of operators. The circuit is simply a single wire of sufficient cross-section to carry the current for one arc, run from the generator to the nearest arc, from there to the next, and so on back to the generator. Wherever it is desired to do welding, a switch is inserted in the line, and a special arc controller provided with suitable connections plugged in across the switch, whenever work is to be done. These controllers may be made portable or permanently mounted at the welding station.

The generator shown in Fig. 1 is a special machine and consists of two units. The generator proper which furnishes the energy for welding; and the regulator, which automatically maintains the current at a constant value. The regulator is excited from a separate source, and by varying its excitation with an ordinary

field rheostat, the main welding current may be set at any value within the range of the machine that is desired, and once set it will automatically maintain that value.

Each arc that is operated on the system is equipped with an automatic controller shown in Fig. 2 which serves two essential purposes as follows:

1—It maintains at all times the continuity of the circuit, so that one arc cannot interfere with any of the others when it comes on, or goes out of the circuit.

2—It controls automatically the heat which can be put into the metal of the weld.

The current through the arc, together with the size of pencil, determines the flow of metal from the pencil, and this current is adjusted by shunting any desired portion of the main current around the arc. The regulation characteristic of the arc is adjusted by a series parallel resistance, which is patented.

For a given flow of metal through the arc, the temperature of the metal is determined by the length of the arc, that is, by the voltage. With this controller, the length of the arc limited by the voltage is adjusted to suit the work and the operator, and if exceeded, the arc is short-circuited automatically and remains short-circuited until the welder is ready to begin again.

Provision is also made for stopping the arc at will without lengthening it. Therefore, with this system it is impossible to draw a long arc and burn the metal, and most important of all, the arc is not broken when the welding operation is stopped, but is killed by a short-circuit which is placed across it.

Stopping an arc by short-circuiting and limiting the heat production in the same way is also patented. A great step in advance has been made by short-circuiting the arc instead of breaking it; because it is impossible to avoid leaving a crater with pin-holes by any other means than reducing heating of the metal, and this is the most effective method of doing it.

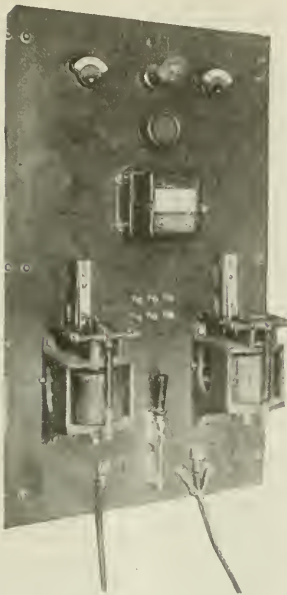


FIG. 2—AUTOMATIC ARC HEAT CONTROLLER FOR CONSTANT CURRENT CLOSED-CIRCUIT OPERATION

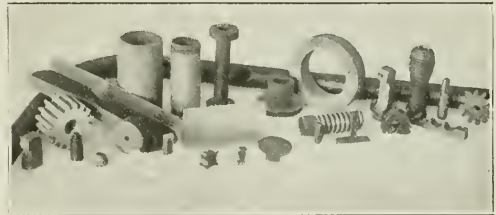
On account of the fact, that the arc heat is automatically controlled and limited, it is possible to use a lower grade of labor in welding operations with this system.

The number of arcs that can be connected in series is limited only by the voltage, and up to the present time, 12 is the maximum for which machines are constructed. Fig. 3 shows the wiring diagram for a system containing three arcs.

A New Non-Corrosive Insulating Compound

A new product with desirable properties is being placed on the market by the Diamond State Fiber Company of Bridgeport, Pa., under the name of condensite-cellulac. It is made by curing fiber and condensite together in one operation and combines the properties of these two substances. It is anhydrous and non-hygroscopic and is impervious to the action of oil or ordinary acids or solvents. It also combines toughness with resistance to the temperatures ordinarily encountered in insulation work.

The chief feature of this material is that it can be made in sheets which are homogeneous and not made up of laminations. It is weather-proof and can be used in



ARTICLES MADE OF CONDENSITE-CELLULAC

apparatus subject to unfavorable conditions of moisture, oil, etc.

It is furnished to the trade in merchantable shapes—sheets, rods, tubes, etc., and is readily machined. It may be formed into very thin sheets (0.015 in. or less) with remarkable accuracy to gage, thereby furnishing an excellent diaphragm material. It is also supplied shaped to customers' specifications. The work as thus supplied is ready for use, having been hardened and made insoluble and infusible by the application of heat.

It is also possible to supply it in the soft uncured state, permitting of its being hardened in the place where it is to be used and thereby formed to fit in spaces or locations with great accuracy. Thus, for instance, gaskets for hot lines, steam, hot water, compressed air, etc., may be accurately fitted to rough flanges and cured in place by the heat of the line, or by applying a certain amount of external heat until the material is hardened.

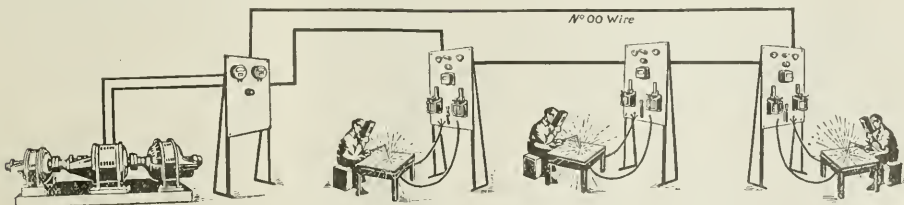


FIG. 3—WIRING DIAGRAM CONSTANT-CURRENT CLOSED-CIRCUIT SYSTEM

Commercial and Industrial Preparedness in Foreign Countries

The whole field of commercial and industrial preparedness for foreign trade promotion, has received increased attention in every important nation of the world since the outbreak of the European war in 1914. The British Government immediately gave instructions to its consular representatives, commercial attaches, and trade commissioners in all foreign countries and the colonies to submit reports on opportunities for British trade occasioned by the cutting-off of the German and Austrian supplying markets. A vast quantity of samples of German and Austrian merchandise which had previously been supplied for use in these markets, was sent in by the British Government representatives, and was placed on display in London. The manufacturers of Great Britain have not only been making merchandise to supply the needs of the army and the government since the war began. They have also been going after foreign markets, and the Commercial Intelligence Branch of the British Board of Trade (an office corresponding to the Bureau of Foreign and Domestic Commerce in Washington) has given them the heartiest of co-operation. Sample exhibits, reports on definite trade opportunities, all sorts of confidential information concerning openings in foreign countries, have been provided by the Commercial Intelligence Branch to an extent previously unheard of in England. The fact that British exports have kept up to such a high level despite the loss of several very important consuming markets because of the war, has been in no small part due to the Government assistance which has been rendered the British trade.

Similarly, in the other European countries engaged in war, foreign trade promotion by the government has been a noticeable feature. In France, the National Office of Foreign Commerce has substantially increased its activities, encouragement has been given to French Chambers of Commerce abroad, and everything in the way of government trade promotion has taken on new life. There has been more active interest in foreign trade, that is, in the export trade in France during the past two years, than there ever was before. At this time there is in this country an important merchant from Paris representing a group of the biggest French manufacturers of fine textiles and wearing apparel. The French government has had a commission of its leading business men visit the United States to study trade opportunities and to make arrangements for increasing commerce between the United States and France during and after the war. In Paris, there has been held a so-called "Reconstruction Exposition." In Lyons, a determined effort has been made to develop the Lyons Fair to rival or even replace the Leipzig Fair.

Of course, industrial and commercial preparedness on the broadest lines has been the subject of the great Paris conference between representatives of England, Belgium, France and Russia, and other allied governments.

In a corresponding manner there has been held the Dresden conference of representatives of the Central Powers and their allies. This conference like the Paris conference had for its purpose the formulation of plans for industrial and commercial preparedness during and following the war.

Germany and Austria have both had substantial government organizations for promoting foreign commerce and while the export trade of these countries has languished somewhat during the war, interest in developing export trade after the war has not in the least diminished. The business men are working right with

the government to see that all possible preparation for intense commercial competition is made.

In Russia, Spain, Italy and Japan, likewise, all possible means for increasing and stimulating present and potential foreign trade are being availed of. Even some of the South American countries that we think of only as suppliers of raw materials and purchasers of manufactured commodities have been able to develop export business in other manufactured goods and are now preparing to extend their business in these commodities.

In the manufacturers and merchants of our country are going to hold the foreign business that they now have, and are going to keep up their end in the commercial competition that is bound to follow the war, it is absolutely necessary that our Government and our business men through their organizations, should leave no stones unturned to be thoroughly prepared. In addition to commercial and industrial preparedness on the part of the business men themselves, we should have the advantage of a better rounded-out service in the Bureau of Foreign and Domestic Commerce, which has done, and is now doing excellent work.

Methods of distribution in South America, Russia and China, involve a study of export and import houses; the position of the foreign manufacturer; different types of middlemen; and different retail agencies, including the department store, chain store, mail order house, and regular retailer.

The investigations into advertising in South America, Russia and the Far East, involve a study of different mediums, including trade papers, newspapers, and other periodicals, cards, billboards, window display and electric sign advertising, with careful attention to the customs and traits of the different peoples.

The handbooks on commercial and industrial conditions to be prepared for Japan and the Dutch East Indies, and Africa, should afford the American business man knowledge of fundamental conditions in these countries that he does not possess in convenient form at the present time.

It is interesting to note that among the investigations to be undertaken by the Bureau of Foreign and Domestic Commerce in the year 1917-18 is one into chemicals, dyes, paints and varnishes for South America.

An Improved Automatic Liquid Weighing Scale

The purpose of any liquid meter is to automatically measure and to record the amounts or quantities of liquids used. This can be done either by simultaneous determinations of the volume and density or by weighing. In determinations of quantities by the first method the density is usually disregarded. Liquid meters may then be divided into two main classes viz.: Volume type machines and weight type machines.

A machine belonging to the latter class is made by the John Simmons Co., 108 Center Street, New York City, and is known as the Leinert automatic gravity scale. Fig. 1 shows a photograph of this machine and Figs. 2 and 3 show sectional drawings. It is used for measuring by weighing such materials as water, oil, sugar juice, ammonia, brine and other liquids, and is not affected by the temperature.

Referring to Fig. 2, the apparatus consists of two measuring tanks of equal size A-1 and A-2, fitted each at one end with one or more siphon pipes C and at the other with weights D. The tanks work on the knife edges, "B," which are located at less distance from the counter weights D, than from the siphon pipes C. The liquid to be measured flows through the inlet pipe E,

passing along the deflector *F* into either tank, for instance as shown, in Fig. 2, into the left hand tank A-1. The weights *D* are so adjusted that the tanks will remain in a horizontal position until they contain a certain definite weight of liquid then they will tilt into the position shown by the dotted lines on Fig. 3, and the

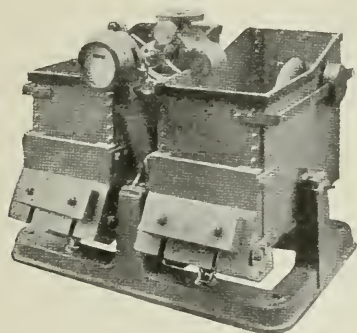


FIG. 1—GENERAL VIEW OF SCALES

liquid will begin to flow through the siphon pipe *C*. After this flow has been started and the level of the liquid in the tank has fallen sufficiently, the tank tilts back again to its original position by the influence of the weights *D* the siphon continuing in action until the tank is emptied. As each tank assumes the position, indicated by the dotted lines Fig. 3, it suddenly tilts the deflector *F* over, so that the liquid, instead of continuing to flow into the tank A-1, begins to flow into the other tank A-2, when the same operation as already

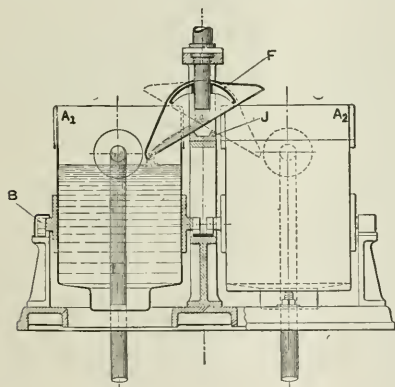


FIG. 2—FRONT SECTIONAL VIEW

described is repeated and continued. It will thus be seen that both tanks are filled automatically with fresh liquid, while the measured liquid runs away into a reservoir, or other receptacle as required. As each tank tips the number of pounds contained is registered on the counter *G*, which is actuated by the deflector *F*.

When either tank is in a horizontal position the deflector *F* rests upon the support *J*, not touching the tanks, therefore the time of tipping and the accuracy cannot be affected, either by the weight of the deflector, or by the pressure of the running liquid in the deflector, or by the resistance in the mechanism of the counter.

In cases when the rate of flow varies considerably, the only source of inaccuracy is the varying quantities

of liquid, which falls into the tank during the time of the tank motion. To eliminate this error a Type B weigher has been devised, in which at the moment of tipping but a small flow feeds the tank, the larger part of the total flow being previously deflected into the other tank by means of a simple float mechanism.

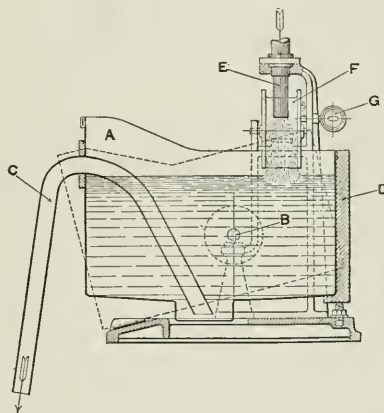


FIG. 3—SIDE SECTIONAL VIEW

In the latest improved type the deflector has been replaced by a circular valve. The machines are made in various sizes, ranging in capacity from 600 lb. per hour to 120,000 lb. per hour for ordinary liquids. It is claimed that an average accuracy of 0.5 per cent can be maintained by the Type A and Type C machines and that the Type B machine will register with an accuracy of 0.4 per cent regardless of changes in temperature or specific gravity of the liquid.

Work of the Bureau of Mines

From the annual report of the Secretary of the Interior we cull the following notes on the work of the Bureau of Mines, omitting the introductory notes on the purpose and chief features of work of the bureau, decrease of accidents in coal mines, rescue and first-aid work, improvement of health conditions in mines, and prevention of coal-mine explosions.

Fuel investigations.—In its efforts to increase efficiency in the use of mineral fuels the bureau is studying the properties of these fuels and the methods of burning them in furnaces and gas producers. Also it is collecting, analyzing, and testing samples of coal purchased under specifications for Government use. In the fiscal year 1916 the aggregate cost of the coal represented by these samples was \$7,800,000. During the year the bureau continued to assist, in the capacity of a consulting fuel engineer, various departments and establishments of the Government in solving problems relating to the purchase of fuel and the efficient use of fuel for heating or power.

Problems of mineral technology.—The mineral technology investigations of the Bureau of Mines cover the minor metals, the rare and the precious metals, the metalloids and the nonmetals, brass and other nonferrous alloys, abrasives, cement, mineral products used as building materials, and many different minerals used in the arts.

In the United States 75,000 persons annually die of cancer, through the radium investigations of the bureau, in cooperation with the National Radium Institute, two great hospitals obtained during the year a

goodly supply of radium for the treatment of that disease. Low-grade radium-bearing ore, heretofore wasted, was concentrated successfully in a mill especially designed for the purpose. This concentrate, as well as high-grade carnotite ore, is being treated at the Bureau of Mines plant at Denver, which is now producing radium at the rate of 5 grams a year. The cost of production since operations began in June, 1914, has been less than \$40,000 a gram, as compared with a market price of \$100,000 to \$120,000 a gram. This radium is not sold, but is to be used in the treatment of cancer.

Incidental to the production of radium at the Denver plant many tons of iron vanadate that can be used in the manufacture of high-grade vanadium steel and many tons of uranium oxide, used in coloring glass and making tool steel, have been produced. For an expenditure of less than \$35,000 the Bureau of Mines will receive as its share of the results of the cooperative agreement at least \$100,000 worth of radium.

In normal times the metal losses in brass melting in the United States annually amount to \$3,000,000, and during the past year of high prices and large production have probably been nearer \$10,000,000. As a result of its investigations of these losses the Bureau of Mines has devised an improved electric melting furnace which will be thoroughly tested on a commercial scale during the coming year. Also, because of the excessive loss of metal, sometimes running as high as 40 per cent, in melting scrap aluminum, the bureau has investigated methods of melting aluminum chips and is publishing the results.

In its clay-industry investigations the bureau has studied methods of so treating the secondary kaolins found in almost unlimited quantities in the Coastal Plain region of Georgia and the Carolinas as to render them applicable to the production of white wares. The results have demonstrated that these kaolins can be cheaply purified and that the purified material is superior to the best English china clay for making china, white crockery ware, and white tile.

Increasing efficiency and lessening waste in the petroleum and natural-gas industries.—Through its petroleum division the Bureau of Mines is investigating problems of technology, engineering, and chemistry in the production and utilization of oil and gas. The petroleum-technology investigations deal chiefly with practicable methods of eliminating waste in drilling wells and of recovering a larger proportion of the oil or gas stored in the productive sands; the engineering-technology investigations deal with storage, the prevention of losses from fires, and the manufacture of gasoline from natural gas; and the chemical-technology investigations deal with the mechanical development of the Rittman process for manufacturing gasoline, toluene, and benzene, and the improvement of methods for analyzing and testing petroleum and petroleum products.

Operators in different fields have been shown the need of properly protecting oil and gas sands from infiltrating water and of sealing wells so as to confine the natural gas securely until such time as it is utilized. Also, the bureau demonstrated the advantages of using mud fluid in drilling wells. Operators in Kansas and in the Blackwell field of Oklahoma are successfully using methods the bureau advocates. In the Blackwell field the operators should recover at least 80 per cent of the gas in the gas sands, whereas in older fields the recovery has been less than 10 per cent. A conservative estimate of the value of the gas that will be saved through the use of approved methods in the Blackwell field is \$20,000,000.

The bureau is cooperating with the Bureau of Indian Affairs in the supervision of oil and gas operations on Indian lands.

Mechanical details of the Rittman process for making gasoline, benzene, and toluene were perfected during the year and the process was shown to be successful on a commercial scale. Tests have indicated how cheaply gasoline can be made from stove distillate.

Various gasolines sold in this country in 1915 were tested to determine their value as motor fuel. Other investigations included the production of gasoline from natural gas and the examination and analysis of petroleum.

Study of metallurgical problems.—In its metallurgical work the bureau continued to cooperate with the Selby and Anaconda smelter commissions, and during the year published as a bulletin the comprehensive report of the Selby Smelter Commission on alleged nuisance and damage occasioned by the Selby smelter in California. Especial attention is being given to the removal of sulphur from smelter gases. Cooperative work with the Anaconda Smelter Commission in the improvement of smoke conditions at the Anaconda smelter in Montana has led to the construction at the smelter of the first units of an electrical apparatus for treating smoke and to the operation of the first units of a sulphuric-acid plant that is to have a daily capacity of 140 tons of acid. Studies to effect the utilization of the acid in the manufacture of phosphates in Montana are in progress.

Under a cooperative agreement with the University of California the bureau has established a mining experiment station at Berkeley, Cal., where it is investigating problems relating to the smelting of lead and copper ores. Some of these problems are the absorption and purification of the sulphur dioxide in smelter smoke and the reduction of the gas to elemental sulphur by the wet Thiogen process. A study of the reduction of barium sulphate, a substance used in making paints and in various chemical industries, was completed.

Other work at Berkeley includes investigation of the improvement of the cyanide and other hydrometallurgical processes for treating ores of gold through the study of the efficiency of machines for crushing ores, the settling of slimes, and the behavior of aluminum in cyanide solutions.

Investigations at the Salt Lake City experiment station, conducted in cooperation with the University of Utah, deal chiefly with methods of preventing wastes in the concentration and metallurgical treatment of non-ferrous ores, especially ores of lead and zinc, with the purpose of making available as ore the great bodies of material now considered waste. Encouraging results have been obtained in the treatment of lead ores by a chloridizing roast and leaching with a solution of common salt, in a volatilization process for treating oxidized ores of zinc, and in investigations of the flotation process for concentrating ores.

An investigation of hazards at blast furnaces in Pennsylvania was made in cooperation with the Pennsylvania Department of Labor and Industry. The dangers peculiar to work about Bessemer converters and open-hearth furnaces at steel plants have been investigated, and an investigation, in cooperation with the Federal Public Health Service, of health conditions in the steel and metallurgical plants of the Pittsburgh district was completed.

Comprehensive studies of the corrosion of metals in mines, with especial reference to damage to mining equipment and the corrosion-resisting qualities of various metals were continued through the year.

Investigation of the fluidity of blast-furnace slags, one purpose of which is to furnish metallurgists and

furnacemen with reliable data for use in smelting lean and complex ores, is being continued, and the results are being published. A new high-temperature viscosimeter has been developed by which the viscosity of slags can be accurately measured to a temperature of 2900 deg. F., or about 900 deg. higher than the highest temperature previously used in viscosity measurements of any substance.

In cooperation with the State School of Mines of Missouri, the bureau is continuing a study of the milling of lead and zinc ores in the Joplin district, Missouri, with particular reference to milling losses and the possibilities of treating the ores by flotation.

Chemical researches.—In addition to the chemical investigations already mentioned, the bureau studied the composition and properties of mine gases and natural gas. The investigations included an absorption method of extracting gasoline from natural gas which, if generally applied, will make possible the recovery of 100,000,000 gal. of gasoline from natural gas each year; the errors that may arise in commercial methods of measuring natural gas at high pressure; the perfecting of a gas detector for use in mines and other places; methods of gas analysis; the chlorination of natural gas with a view to making tetrachloride, chloroform, and other valuable products; and the fusibility of coal ash as related to the formation of clinker in fuel beds.

Other investigations.—Special investigations that were described in reports published during the year or are still in progress include placer-mining methods, especially the use of gold dredges; iron-ore mining and iron making in the United States; utilization of low-grade fuel; gas-producer practice; and factors controlling the use and the market prices of fuel.

Personal

Mr. J. W. Beckman, consulting chemical engineer of the Great Western Power Co. and the Great Western Electrochemical Co. of San Francisco, Cal., and Mr. H. E. Linden, formerly associated with Stone & Webster, have formed the Beckman & Linden Engineering Corporation, with offices at 604 Balboa Building, San Francisco, and closely associated with it will be the Chemical Development Corporation. The object of this corporation will be primarily to develop uses and processes for the handling of many of the dormant resources available on the Pacific Coast.

Messrs. Frederick G. Cottrell and Dorsey A. Lyon of the United States Bureau of Mines were in Golden, Col., recently, conferring with R. B. Moore of the Colorado branch of the bureau and the authorities of the Colorado School of Mines relative to the co-operative investigations which are to be undertaken next year.

Mr. J. V. N. Dorr was recently a visitor in Denver in connection with business at the Denver office of the Dorr Company.

Mr. R. S. Foster has resigned his position as safety engineer at the Butte Mines of the Anaconda Copper Co. and has accepted a position with the Doe Run Lead Co. at Flat River, Mo., in a similar capacity.

Mr. Geo. C. Hicks, Jr., vice-president and engineer of the P. H. and F. M. Roots Co. of Connerville, Ind., for the past fifteen years, announces his retirement from the company on Jan. 1, 1917. Mr. Hicks will act as consulting engineer for the company for a short time. Before taking up work again he expects to take a six months' vacation.

Mr. R. H. Hodge, formerly foundry expert of the Western Foundry & Machine Co., is now superin-

tendent of the Ogden Iron Works, which is erecting a plant at Ogden, Utah. Mr. George J. Silver, formerly manager of the Western Foundry & Machine Co., will be consulting engineer.

Mr. Dyke V. Keedy, consulting and metallurgical engineer, of 6 Beacon Street, Boston, Mass., has gone to South America on professional business, to be gone some three months.

Mr. K. L. Kithill, head of the Arizona branch of the Bureau of Mines at Tucson, Ariz., has resigned his position with the government, and anticipates entering in business for himself at Denver.

Mr. L. O. Koven was the recipient on Dec. 21 of a sterling silver set consisting of six individual plates and tray, suitably inscribed, as a token of appreciation from the Eastern Supply Association, of which Mr. Koven was the president for the last three years.

Mr. A. R. Levin has been appointed New York manager for the Supplee-Biddle Hardware Company, Philadelphia, Pa., with offices at 30 Church Street.

Mr. I. L. Merrill, president of the Hedley Gold Mining Co., has left his home at Los Angeles, Cal., to inspect the company's properties at Hedley, B. C., Canada.

Mr. C. E. Mills has been elected as managing director for the Cananea Consolidated in Sonora, Mexico. Mr. Mills was the well known general manager of the Inspiration Consolidated, previous to the acceptance of his new position.

Mr. Robert Schubert, metallurgical engineer, sailed for Stavanger, Norway, on Dec. 28, to accept a position with the Stavanger Electro Staalwerk.

Mr. Francis P. Sinn of the New Jersey Zinc Co., Palmerton, Pa., has been elected a director of the National Safety Council. The council has a new section devoted to copper, lead and zinc smelting plants.

Mr. Stanley M. Tracy, until recently western district manager in the Chicago office of the Driver Harris Wire Co., is now assistant general sales manager at the main office and works of the company, Harrison, N. J.

Mr. F. H. A. Wielgolashi, a prominent engineer and nitrate expert from Norway, has recently come to Puget Sound in the interests of the American Nitrogen Products Company. He is now supervising the operation of the furnaces at the company's plant at La Grande, Wash., of which he is the inventor and will have direct charge of the plant for several months.

Mr. T. K. Wilkinson has returned to the Baltimore Copper Smelting & Rolling Company, Baltimore, Md., after an absence of two years.

CURRENT MARKET REPORTS

The Iron and Steel Market

The iron and steel market has continued dull by comparison with the intense activity that characterized the month of November. Strictly new buying has been light in both pig iron and finished steel, and there has been some decrease in specifications filed against finished steel contracts. Before the holidays the disposition to "go slow" was attributed almost exclusively to the suggestion that peace terms might be arranged for the European belligerents but the more mature reflection of the trade has led to the conclusion that nothing occurred that might not have been expected at almost any time. There was no occasion to assume that the war would never end, or to assume the impossible, that no peace overture would be made without several months' advance notice being given. The disposition now is to give more weight to the idea that the excited buying movement had to end soon by exhausting its force, and

the double influence of the peace overture and the holidays chanced to stop it rather suddenly.

There is no decrease whatever in the demand for material. It is simply in the making of additional engagements that a slowing down has occurred. Buyers are exerting as much pressure as ever upon mills to expedite their deliveries, and perhaps even more, as the partial breakdown of the transportation system of the country, under an unprecedented load, has slightly curtailed deliveries and occasioned fears that there would be a still more serious interruption to traffic.

It is only because the weather has been unseasonably mild that transportation has been maintained so well. A really cold snap would probably make more serious trouble than has yet been experienced. At Christmas time between twenty-five and thirty-five blast furnaces were banked on account of not receiving coke, chiefly from the Connellsville region, and many others were forced to slow down a trifle. At this writing nearly all the banked furnaces have resumed, partly on account of coke accumulating, but pig iron production is still distinctly less than the physical capacity. During the holidays there were considerable accumulations of finished steel at various works, partly by reason of car shortages and partly on account of embargoes. There have been frequent changes of rolling schedules on account of embargoes, and even those changes tend to cut down. At the moment very little steel is accumulating at mills but no progress to speak of has been made toward moving steel already accumulated. The industry is booked for serious times in the next two months and is much more concerned with production and transportation problems than with market problems.

PIG IRON

The pig iron market has been practically stationary as to prices. There is scarcely any inquiry for deliveries in the second half of the year, while there is a fair run of inquiry for earlier deliveries, ranging from spot to first half. In foundry and malleable grades premiums for quick delivery of small lots are usually obtained. Basic iron may be a shade easier than thirty days ago for second half delivery, but is correspondingly stiffer for early deliveries. There is an excellent run of export demand, but the governing factor is the vessel situation. If there were more vessel room much more export iron could be sold. Bessemer iron is quotable at \$35 and basic iron at \$30, f.o.b. valley furnaces.

UNFINISHED STEEL

There is an almost complete absence of offerings of unfinished steel in any form. Brokers and merchants are constantly scouring the trade but only occasionally find an odd lot. The mills do not quote for forward delivery at all. For soft steel in the form of billets, blooms, slabs, sheet bars, etc., export bids are generally at least \$60, Pittsburgh or Youngstown, and sometimes run a little above that figure. Soft steel rods have brought \$75.

FINISHED STEEL

Prices of finished steel are practically stationary. Last advances were \$2 a ton in bars, plates and shapes, Dec. 20, as already reported, and \$4 a ton in wrought iron and steel pipe, Dec. 30. There is no expectation of further changes in steel prices for some time to come, or until distinctly new developments occur. There is no basis upon which prices could well be advanced, for delivery at mill convenience, as there is not much inquiry for the late deliveries, and the turnover in prompt material is so light that no very definite market is established at any time. There is certainly nothing in pros-

pect that would tend to depress prices, for the mills are more than comfortably filled with business for months and there is no incentive for any seller to cut prices.

Naturally, there is speculation as to what would occur were definite steps undertaken for the establishment of peace. By far the major part of the business on books of steel mills is for domestic consumption, of a character that would continue, peace or war. Buyers would expect an eventual readjustment in prices, but in the great majority of cases would not be in position to await the readjustment. While the view certainly has not been generally expressed, there is reason to doubt whether a continuance of the war, say for two years more, might not seriously decrease the demand for steel. The shipping situation is such that exports cannot be increased and the extremely high prices now current should tend eventually to alter the balance between domestic demand and production, seeing that production is increasing steadily except as interfered with by transportation conditions. It is more generally believed than formerly that the peace demand for steel, once prices have been readjusted, will be very large.

Non-Ferrous Metal Market

Monday, Jan. 8.—The markets in all the metals continue dull and both buyers and sellers have been holding off awaiting future developments. The statistics show 1916 to have been a most remarkable year both in production and value of product. Copper shows signs of developing some weakness, but this may only be temporary. Lead is strong and tin is steady. Spelter is unchanged in a dull market.

Copper.—Business in copper continues dull and consumers continue to be sellers along with producers and dealers. A feature of the market is the little interest shown in futures beyond March. Prices have declined for prompt delivery from 31.50 cents asked for both electrolytic and Lake on Dec. 23 to 28.25 cents for electrolytic and 29.00 cents for Lake on Jan. 5. The large producers are holding off and are holding their quotations on third and fourth quarter deliveries at 6.00 to 7.00 cents above the outside market. February delivery is quoted at 28.50 for Lake and 27.75 for electrolytic. First quarter electrolytic is held at 27.75, second quarter at 26.00 to 27.00, third quarter at 25.00 to 26.00, and fourth quarter at 24.00 to 25.00 in the outside market.

The copper statistics issued by the Geological Survey show an increase of 540,000,000 lbs. in smelter production in 1916 and an increase of 677,000,000 lbs. in refinery production. The refinery production is given as 2,311,000,000 lbs., and the smelter production as 1,928,000,000 lbs. The exports as given by the American Metal Market Report were 760,000,000 lbs., leaving 1,633,429,666 lbs. available for home consumption. How much of this was actually used is not known. A large demand for copper is expected from Germany after the war and Canada will probably want considerable shortly in view of her large munitions contracts, but whether domestic consumption will be large enough to take care of the balance not exported in 1917 will be a feature which will be watched with interest, as refinery capacity is being still further increased.

Tin.—The market has shown an improvement and on Jan. 1 Straits had advanced £3 10s. to £182 5s., with a similar advance in Standard. Our price for prompt delivery Straits jumped to 43.00 cents on Jan. 2, but has since eased off to 42.50 on little interest being shown by buyers. Deliveries in December, 1916, were 4082 tons, which are below normal. The total visible supply, including stocks afloat and on hand in all countries on Dec. 31 was 20,737 tons, or over 4000 tons

more than at the same time last year. The stocks in the United States were 3511 tons.

Lead.—Lead is unchanged and the market has continued dull but firm. The trust price is still on the basis of 7.50 cents New York with the outside price 7.50 to 7.62½. The production in 1916 was a new record of 579,600 tons. Exports are estimated at 108,200 short-tons lead produced from domestic ore, a gain of 21,000 tons over 1915. The domestic demand is large and partly explains the small amount for sale.

Spelter.—Spelter has remained quiet and practically unchanged, at 9.67½ to 9.92½ New York for prompt shipment. Futures are slightly lower on account of the small demand. February is quoted at 9.55 to 9.80, March at 9.42½ to 9.67½, and second quarter at 8.92½ to 9.17½. The production in 1916 was 658,000 tons, or an increase of 34 per cent over 1915. Exports were 210,500 tons, or an increase of 59 per cent. Domestic consumption increased 22 per cent. The low prices prevailing at present are the result of production overtaking the demand.

Other Metals.—Antimony is unchanged at 14.25 to 14.50. Aluminum is unchanged at 60.00 to 64.00 cents for the No. 1 Virgin metal. Magnesium is unchanged at \$3.50 per lb. Electrolytic nickel is 50.00 cents per pound; Cadmium \$1.50; Cobalt \$1.50 and quicksilver \$90.00 per flask; tungsten ore is \$17.50 to \$20.00 per unit and silver 75½ cents.

Chemical Market

There has been a decided lull in practically all branches of the chemical trade during the past fortnight. The holidays interfered with prompt and nearby business to a marked degree and as a result of the peace negotiations, contracts have been invariably held up. Heavy chemicals that have been slowly but steadily advancing the past two or three months recorded marked declines at the first announcement of the possibility of peace and have not recovered. There is a probability that higher prices will be reached for deliveries in nearby positions with contract business holding fire until the peace question is definitely decided.

As a result of this condition and the likelihood of munition contracts halting, glycerin has been subject to a rather sharp decline. For C. P. and dynamite business has passed as low as 53c, although the general asking price is 1c. to 2c. higher. The C. P. and dynamite grades are quoted on about the same level at the moment.

Potassium cyanide is now practically off the local market. The sodium and the mixture are being traded in to some extent with the former quoted at about \$1.75 to \$1.85 spot and the mixture at \$2.05. Future shipments from Japan are offered at lower figure, sodium cyanide for example, at \$1.20. But small amounts of Japanese material are en route so that the spot market is not affected.

Soda ash, caustic soda, bichromates of soda and potash and bleaching powder have not recovered from the decline recorded coincident with the announcement of peace negotiations and contract business has been almost entirely suspended.

Despite an enormous production, sulphuric acid is selling at a somewhat higher level. Important Pennsylvania producers are asking \$30 for 66 degree brimstone f.o.b. Some business of this description has passed at \$28 however. The production of acid in the United States last year was enormous. In the absence of positive figures it is possible to arrive at a fairly accurate estimate. The imports of pyrites totaled 1,500,000 tons. The total consumption was possibly 2,300,000 tons. On the basis of 50 per cent sulphur con-

tent of this ore and a theoretical recovery of 2.35 tons of acid from each ton of pyrites consumed, the production of pyrites acid would have been approximately 5,400,000 tons of 50 deg. Baume acid. This figure does not include the acid production from brimstone, statistics of which are not available. The brimstone acid production in 1916 was the heaviest on record. The actual production of both brimstone and pyrites acids in 1915 was 3,868,152 tons.

Other mineral acids have not been subject to much change. Nitric acid, so important with munition manufacturers, has remained stationary, but the feeling was an easier one. Muratic acid business continues spasmodic.

In the coal tar classification, there have been freer offerings of aniline oil, dinitrophenol and phenol. The aniline oil market appears to be suffering more from keen competition than from an over-production, as there are hardly more than fifteen active producers at the moment. As a result of new manufacturers entering the field, offerings of dinitrophenol are more abundant and prices are easier. As a result of a refusal of one large consumer to accept contract deliveries, surplus stocks reached the open market and prices were easier. This condition is temporary, however. Most phenol producers are well sold out.

Benzol is somewhat firmer. The leading producers have advanced prices somewhat. The production is well covered by contract. Toluol for delivery next year is particularly scarce and large manufacturers advise that the only stocks that will be available will be surplus stocks over their contracts.

Alcohol business has been quite large and the market has held up well in view of the heavy business. Production is proceeding upon a record scale.

Arsenic has advanced with stocks light. All producers have marked up selling prices. This is, perhaps, incidental to the season as manufacturers of paris green and spraying solutions are preparing for an active spring season.

Sulphate of copper has been subject to practically no change during the fortnight. Firmness expected has not materialized as the export business absorbed a great bulk of this production and the peace negotiations have, of course, suspended important business for foreign account.

Sulphate of ammonia, except for resale lots, is practically out of the market. Producers are sold, as a rule, six months ahead. The 1916 production of ammonia reduced to the sulphate equivalent is figured as 325,000 tons, an increase of 113,000 tons over 1915.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET JANUARY 8, 1917

Acetone, Drums	100 lb.	2.24	21
Acid, acetic, 28 per cent	100 lb.	3.75	7.75
Acetic, 56 per cent	100 lb.	8.00	8.25
Acetic, glacial, 99½ per cent, carboys	lb.	.32	.35
Boric, crystals	lb.	.13	.13½
Citric, crystals	lb.	.01½	.06
Hydrochloric, commercial, 18 deg.	lb.	.01½	.013½
Hydrochloric, 20 deg	lb.	.02	.02
Hydrochloric, C. P., conc., 22 deg	lb.	.02	.02½
Hydrochloric, 30 per cent, in barrels	lb.	.01½	.05½
Lactic, 44 per cent, light	lb.	.13½	.14½
Lactic, 22 per cent	lb.	.06½	.07
Nitric, 36 deg	lb.	.04½	.05
Nitric, 42 deg	lb.	.05½	.06
Oxalic, crystals	lb.	.44	.45
Phosphoric, 55 per cent	lb.	.30	.32
Picric	lb.	.60	.75
Pyrogallol, resublimed	lb.	3.10	3.25
Sulphuric, 60 deg	ton	20.00	21.00
Sulphuric, 66 deg	ton	27.00	30.00
Sulphuric, oleum (Fuming), tank cars	ton	35.00	40.00
Tannic, U. S. P. bulk	lb.	.88	.92
Tartaric, crystals	lb.	.66	.67
Alcohol, grain, 188 proof	gal.	2.68	2.70
Alcohol, Wood, 95 per cent	gal.	.88	.90
Alcohol, Dehydrated, 180 proof	gal.	.65	.66
Alum, ammonia lump	lb.	.04	.04½
Alum, chrome	lb.	.21	.22
Alum, potash lump	lb.	.65	.66

Intermediates, Etc.

Aluminum sulphate, technical	lb.	.017	.024	Alpha naphthyl am ne.	lb.	1.00	1.25
Aluminum sulphate, iron re.	lb.	.034	.041	Aniline oil	lb.	.214	.224
Ammonia aqua, 26 deg. carbons	lb.	.054	.054	Aniline salts	lb.	.28	.30
Ammonia, anhydrous	lb.	.124	.13	Anthracene, 80 per cent.	lb.	.175	.500
Ammonium carbonate	lb.	.134	.14	Benzaldehyde	lb.	1.80	1.90
Ammonium nitrate	lb.	.014	.014	Benzidine Base	lb.	1.50	1.65
Amyl acetate	gal.	4.25	4.50	Benzidine, Sulphate	lb.	8.50	9.00
Arsenic, white	lb.	.084	.094	Benzoic acid	lb.	.90	.95
Arsenic, red	lb.	.65	.70	Beta naphthol Sublimed	lb.	—	—
Barium chloride	ton	90.00	95.00	Dierbol benzol	lb.	—	—
Barium sulphate (Blanc Fixe) powder	lb.	.01	.012	Dimethylamine	lb.	.55	.57
Barium nitrate	lb.	.11	.12	Diphenylamine	lb.	2.15	2.25
Barium peroxide	lb.	.40	.50	H acid	lb.	1.50	1.75
Bleaching powder, 35 per cent	lb.	.0115	.0120	Metaphenylene diamine	lb.	.60	.62
Borax, crystals, sacks	lb.	.074	.08	Monochlorobenzal	lb.	.30	.32
Bromine, etials	ton	28.00	29.00	Naphthalene Flake	lb.	2.00	2.10
Bromine, technical	lb.	1.20	1.30	Naphthalene acid, crude	lb.	1.00	1.05
Calcium acetate, crude	lb.	.034	.034	Ortho-aminophenol	lb.	1.50	1.60
Calcium carbide	ton	68.00	75.00	Ortho-toluidine	lb.	4.50	6.00
Calcium chloride, 70-75 per cent, fused, lump	ton	21.50	22.00	Paranitrophenol	lb.	1.60	1.75
Calcium peroxide	lb.	—	—	Paraphenylenediamine	lb.	3.50	3.75
Calcium sulphate	lb.	—	—	Para-toluidine	lb.	2.00	2.10
Carbon phosphide	lb.	—	—	Resorcin, technical	lb.	.51	.53
Carbon bisulphide	lb.	.054	.06	Resorcin, pure	lb.	8.75	9.50
Carbon tetrachloride, drums	lb.	.114	.16	Salicylic acid	lb.	20.00	22.00
Caustic potash, 88-92 per cent	lb.	.81	.86	Sulol	lb.	2.25	2.30
Caustic soda, 70 per cent	lb.	.014	.014	Sulphanilic acid	lb.	.40	.45
Chlorine, liquid	lb.	.14	.20	Toluidine-mixture	lb.	1.00	1.10
Coppers	100 lb.	1.10	1.25				
Copper carbonate	lb.	.70	.37				
Copper cyanide	lb.	.124	.124				
Copper sulphate 99 per cent large crystals	lb.	.38	.40				
Cream of tartar, crystals	100 lb.	1.634	1.80				
Epsom salt, bags	lb.	.114	.12				
Formaldehyde, 40 per cent	100 lb.	.75	.80				
Glauber's salt	lb.	.53	.54				
Glycerine, bulk c. p.	lb.	.60	12.00				
Hydrogen peroxide, gross	lb.	4.00	4.25				
Iodine, resublimed	lb.	.024	.10				
Iron oxide	lb.	.034	.014				
Iron sulphate	lb.	.13	.134				
Lead acetate, white crystals	lb.	.084	.084				
Lead arsenate	lb.	.154	.16				
Lead nitrate	lb.	.084	.09				
Litharge, American	lb.	1.00	1.05				
Lithium carbonate	lb.	.66	.70				
Manganese dioxide	lb.	.124	.15				
Magnesium carbonate, tech	lb.	.14	.14				
Nickel salt, single	lb.	.114	.114				
Nickel salt, double	lb.	1.00	1.10				
Phosphorus, red	lb.	.85	.90				
Phosphorus, yellow	lb.	.40	.41				
Potassium bichromate	lb.	1.30	.34				
Potassium bromate, granular	lb.	.34	.36				
Potassium carbonate calcined, 80-85 per cent	lb.	.64	.65				
Potassium chlorate, crystals	lb.	2.15	2.50				
Potassium cyanide, 98-99 per cent	lb.	3.15	3.50				
Potassium iodide	ton	435.00	450.00				
Potassium muriate, 80-85 p. c., basis of 80 p. c.	lb.	.27	.30				
Potassium nitrate	lb.	2.65	3.00				
Potassium permanganate	lb.	.91	.93				
Potassium prussiate, red	ton	263.00	275.00				
Potassium prussiate, yellow	lb.	.33	.34				
Potassium sulphate, 90-95 p. c., basis 90 p. c.	lb.	.14	.14				
Rochelle salts	lb.	.174	.18				
Salt ammonia, gray, gran	100 lb.	1.00	1.10				
Salt ammonia, white, gran	lb.	.70	.75				
Salt soda	lb.	.464	.464				
Salt cake	lb.	.0290	.0295				
Silver cyanide	lb.	.0340	.0350				
Silver nitrate	oz.	.12	.13				
Soda ash, 58 per cent, light, flut	lb.	8.00	8.50				
Soda ash, 58 per cent, dense, flut	lb.	1.60	1.70				
Sodium acetate	lb.	.17	.174				
Sodium bicarbonate	lb.	.05	.054				
Sodium bisulphate, powd.	lb.	.25	.26				
Sodium chloride	lb.	1.80	1.90				
Sodium fluoride, commercial	lb.	.014	.014				
Sodium hyposulphite	100 lb.	3.274	3.324				
Sodium nitrate, refined	lb.	3.25	3.30				
Sodium nitrite	lb.	1.10	1.20				
Sodium peroxide	lb.	.014	.05				
Sodium phosphate	lb.	.31	.32				
Sodium prussiate yellow	100 lb.	.80	.80				
Sodium silicate, liquid	lb.	.024	.024				
Sodium sulphide, 30 per cent crystals	lb.	.12	.124				
Sodium sulphite	lb.	.44	.50				
Strontium nitrate	lb.	.394	.40				
Sulphur chloride, drums	100 lb.	2.30	2.32				
Sulphur, flowers, sublimed	100 lb.	1.95	2.00				
Sulphur, roll	ton	35.00	35.00				
Sulphur, crude	lb.	1.34	1.35				
Tin bichloride, 50 deg.	lb.	.46	.47				
Tin oxide	lb.	.24	.25				
Zinc carbonate	lb.	.12	.13				
Zinc chloride	lb.	.50	.50				
Zinc cyanide	lb.	.22	.26				
Zinc dust	lb.	.104	.114				
Zinc oxide, American process XX	lb.	.064	.064				
Zinc sulphate	lb.	—	—				

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.57	.60
Benzol, 80 per cent.	gal.	.55	.60
Toluol, pure, water white	gal.	1.70	1.90
Xylol, pure, water white	gal.	1.00	1.20
Solvent naphtha, water white	gal.	24	28
Solvent naphtha, crude heavy	gal.	.15	.20
Creosote oil 25 per cent	gal.	.374	.32
Dip oil 20 per cent	gal.	.25	.30
Creosote oil 25 per cent	ton	12.00	14.00
Carbolic acid, crude, 95 to 97 per cent.	lb.	.80	.85
Carbolic acid, crude, 50 per cent	lb.	.60	.65
Carbolic acid, crude, 25 per cent	lb.	.28	.30
Cresol, U. S. P.	lb.	.18	.20
Cresylic acid, refined No. 5	lb.	.19	.22

Petroleum Oils

CRUDE (AT THE WELLS)

Pennsylvania	bbbl.	2.95	—
Cornish, Ohio	bbbl.	2.20	—
Somerset, Ky.	bbbl.	2.10	—
Wooner, Ohio	bbbl.	1.90	—
Indiana	bbbl.	1.60	—
Illinois	bbbl.	1.72	—
Oklahoma and Kansas	bbbl.	1.60	—
Caddo, La., light	bbbl.	1.50	—
Corsicana, Tex., light	bbbl.	1.20	—
California	bbbl.	.74	—

LUBRICANTS

Black, reduced, .29 gravity, 25-30 cold test	gal.	.134	.14
Cylinder, light	gal.	.46	.26
Cylinder, dark	gal.	.18	.19
Extra, cold test	gal.	.26	.31
Paraffine, high viscosity	gal.	.294	.30
Paraffine, 903 spec. gr.	gal.	.214	.19
Paraffine, 865 sp. gr.	gal.	.184	—

Flotation Oils

Pine oil, steam distilled	gal.	.58	—
Pine oil, destructively distilled	gal.	.46	—
Pine-tar oil	gal.	.19	—
Pine-tar oil, double refined	gal.	.27	—
Pin oil, light	gal.	.37	—
Pine oil, heavy	gal.	.18	—
Pine tar, thin	gal.	.18	—
Turpentine, crude	gal.	.38	—
Hardwood oil, f.o.b. Michigan	gal.	.16	—
Creosote, coal tar, acid	gal.	1.54	—
Creosote, coal tar, neutral	gal.	.214	—
Coal tar, thin	gal.	.11	—

Vegetable and Other Oils

China wood oil	gal.	.12	.124
Cottonseed oil, crude	gal.	.81	.82
Liaosseed oil, raw	gal.	.92	—
Peanut oil, crude	gal.	.35	.86
Rosin, 280 lb	bbbl.	6.55	—
Rosin oil, first run	gal.	.38	—
Soya bean oil, Manchuria	gal.	.12	.124
Sperm oil, bleached winter, 38 deg.	gal.	1.03	1.05
Turpentine, spirits	gal.	.55	.56

Miscellaneous Materials

Barytes, floated, white	ton	25.00	35.00
Beeswax, white, pure	lb.	.45	.50
Caruba wax, highest grade	lb.	.50	.52
Chalk, light, precipitated, English	ton	8.04	8.04
Feldspar	lb.	8.04	12.00
Fuller's earth, powdered	100 lb.	.80	1.05
Plaster of Paris	bbbl.	1.50	1.70
Red lead, dry, carloads	ton	10.00	12.50
Soapstone	ton	10.00	13.00
Talc, American, white	ton	10.00	13.00
White lead, dry	lb.	—	.84

Refractories, Etc.

(F.O.B. WORKS)

Chrome brick	net ton	120.00	130.00
Clay brick, cement, Grecian	net ton	80.00	90.00
Magnesite, Grecian, dead burned	net ton	85.00	90.00
Magnesia brick, Grecian, 9x4x2 1/2	net ton	135.00	140.00
Silica brick	per 1000	40.00	45.00

Ferroalloys

Ferro-carbon-titanium, carloads	lb.	.08	—
Ferrochromium	ton	—	Nominal
Ferromanganese, domestic, delivered	ton	165.00	175.00
Ferromanganese, English	ton	165.00	—
Ferromolybdenum	lb.	4.00	—
Ferrosilico, 50 p. c. carloads, del. Pittsburgh	ton	100.00	—
Ferrotungsten, 75-85 p. c. f.o.b. Pittsburgh	lb.	2.30	—
Ferrovannadium, f.o.b. works	lb.	2.75	3.00

INDUSTRIAL

Financial, Construction and Manufacturers' News

Financial

Alliance Brass Foundry Co., Detroit, Mich., has been incorporated with a capital of \$50,000 to deal in machines. Incorporators are A. Manche, E. M. Sloman, D. W. Berry.

Alumite Corporation, Wilmington, Del., has been incorporated with a capital of \$20,000 to mine gold and silver.

American Explosives Co., St. Louis, Mo., has been incorporated with a capital of \$50,000. Incorporators are E. B. McAbee, E. Cole and J. H. Robb. Manufacture of deal in explosives.

American Fuel Company, Atlantic City, N. J., has been incorporated with a capital of \$500,000.

American Magnesium Corp., Niagara Falls, N. Y., has been incorporated with a capital of \$300,000 to manufacture and deal in magnesium, calcium, metals, coal, coke, etc. Incorporators are J. J. Devereaux, L. J. Hallenbeck, E. W. Burdick, 445 West 153d Street, New York.

Armour & Co., the Chicago packers, has purchased four of the largest tanneries in the Punksutawney, Pa., district, viz., The Big Run Tannery, the Gleasontown Tannery, the Driftwood Tannery, and the Merdix Run Tannery. The amount involved is believed to be about \$1,000,000.

Aroostook Pulp & Paper Co., Inc., Boston, Mass., has been incorporated with a capital of \$500,000. Incorporators are A. B. Flaming, G. S. Lewis, S. F. Johnson, H. Ketchum, E. T. Connolly, E. P. Lindsay.

Atlantic Potash Co., Eddyville, N. Y., has been incorporated with a capital of \$177,500 to deal in chemicals. Incorporators are S. E. Howard, S. A. Anderson, A. W. Britton, 65 Cedar Street, New York.

Bardeen Paper Co., Otsego, Mich., has increased its capital from \$175,000 to \$1,000,000.

The Benzol Products Company has increased its capital from \$1,000,000 to \$1,500,000.

Bowditch Dye Works, Inc., Boston, Mass., has been incorporated with a capital of \$10,000 to deal in cotton, wool, rays, dyes, etc. Incorporators are G. A. Vaughn, Dexter Elliott, E. Linesey, Jr., F. Ashton.

Bridgeport Iron & Metal Co., Bridgeport, Conn., has been incorporated with a capital of \$50,000. Incorporators are W. Alderman, Ansonia; P. Nowitz, Bridgeport; A. Alderman, Ansonia.

Bristol Power, Pulp & Paper Co. has been incorporated in Delaware with a capital of \$1,000,000 to deal in wood, paper, etc. Incorporators are M. Dougherty, M. C. Donohue, F. Giles, all of Wilmington.

Burd-Beidler Metals Corp., New York, has been incorporated with a capital of \$1,500,000 to manufacture hardware, mechanical appliances, jewelry and novelties. Incorporators are L. Burd, W. A. Leonard and J. F. Lynch, of New York City.

Burdett Gas Service Corporation, Wilmington, Del., has been incorporated with a capital of \$3,000,000 to manufacture gas oxygen and any article in which gas is used.

California Fiber & Pulp Co., Los Angeles, Cal., has been incorporated with a capital of \$50,000. Incorporators are A. J. Hime, E. C. Stegall, E. W. Bothwick, R. B. Turnbull, J. B. Meikle.

The Carbon Block Mining Co., Cincinnati, Ohio, has been incorporated with a capital of \$25,000. Incorporators, G. Rapp, and others.

The Carso Paper Co., Dansville, N. Y., has been incorporated with a capital of \$100,000. Incorporators are J. R. Carter, J. A. Ault, H. T. Kechev, L. C. Anderson, W. R. Carter, E. A. Carter.

Carson Hill Consolidated Gold Mines, Portland, Me., has been incorporated with a capital of \$300,000 to mine, mill, smelt and prepare all kinds of metals and ores, etc., for market.

Cayuga Tool Steel Co., Auburn, N. Y., has been incorporated with a capital of \$300,000 to manufacture furnaces, mills, iron and steel. Incorporators are J. B. King, J. H. Richards, H. D. Canaday, 2114 Canto. Avenue, Brooklyn, N. Y.

Central Cressosting Co., Winnetka, Ill., has been incorporated with a capital of \$200,000 to engage in general cressosting business. Incorporators are P. Kimmier, R. Swanson, E. S. Burling, H. Wood.

The Central Sugar Corp., Albany, N. Y., has been incorporated with a capital of \$3,400,000 to conduct a sugar plantation refinery and raise sugar. Incorporators are H. P. Dubois, F. S. Connett, F. J. Bomm, of New York City.

Chemical Pigment Co., Baltimore, Md., has been incorporated with a capital of \$255,000 to manufacture pigment and chemical products.

Chemical Products Corp., Camden, N. J., has been incorporated with a capital of \$200,000 to deal in chemicals. Incorporators are F. R. Hansell, J. A. MacPeak, I. C. Clow.

The C. H. Clark Oil Co., Cleveland, Ohio, has been incorporated with a capital of \$20,000 to deal in paints. Incorporators are I. T. Quick, J. M. Cantillon, C. H. Clark, I. M. Clark, A. R. Lawrence.

The Cleveland Foundry Co., the Cleveland Metal Products Co., and the Cleveland Factory Co. have announced to stockholders a plan of consolidation into a \$10,000,000 Metal Products Co. The Cleveland Foundry Co. produces oil stoves, the Cleveland Metal Products Co. sheet aluminum and holding concerns, and the other company is a realty concern.

Commercial Acid Co., E. St. Louis, Mo., has been incorporated with a capital of \$150,000. The company was organized by W. H. Cocke, J. W. Garbard and G. M. Byrns to manufacture and sell chemicals.

Concord Mining Co., Webb City, Mo., has been incorporated with a capital of \$100,000 to conduct a general mining business. Incorporators are C. E. Crane, F. S. Gardiner, F. Gray.

Consumers Explosives Co., Augusta, Me., has been incorporated with a capital of \$750,000 to manufacture explosives. Incorporators are E. M. Leavitt, E. L. McLean.

The Dellerbrook Chemical Co., Lima, Ohio, has been incorporated with a capital of \$50,000. Incorporator, E. R. Dellerbrook.

Dento Chemical Co., Dover, Del., has been incorporated with a capital of \$500,000 to carry on the business of chemists and druggists.

The Detroit Copper & Brass Rolling Mills, Detroit, Mich., has been incorporated with a capital of \$3,000,000.

Duall Leather Corp., New York, has been incorporated with a capital of \$630,000 to manufacture and deal in leather, textile fabrics. Incorporators are C. G. Quinn, C. A. Meier, W. McCarroll, 152 Broadway.

The Federal Dyestuff and Chemical Corporation, Kingsport, Tenn., has increased its capital from \$1,500,000 to \$2,000,000.

Goodwater Granite Co., Inc., Philadelphia, Pa., has been incorporated with a capital of \$550,000 to manufacture granite, iron and steel. Incorporators are W. L. Shumate, Jr., Birmingham, Ala.; Eugene Argen, and T. D. Ephes, Goodwater, Ala.

The Grand Rapids Grinding Co., Grand Rapids, Mich., has been incorporated with a capital of \$25,000 for manufacturing and selling machinery and metal goods. Incorporators are S. Owen, Livingston C. P. Hext, J. DeKoning.

Hattlesburg Pulp & Board Co., Portland, Me., has been incorporated with a capital of \$1,250,000 to manufacture pulp and paper.

Holland Aniline Co., Holland, Mich., has been incorporated with a capital of \$250,000 to manufacture and deal in aniline dyes. Incorporators are Frans Franklin and V. C. Maize, of Holland, and L. Weisberg, of Chicago.

Wood Foundry Co., Wilmington, Del., has been incorporated with a capital of \$50,000 to manufacture iron castings, steel castings, etc.

Ideal Piece Goods Dyeing Co., Paterson, N. J., has been incorporated with a capital of \$100,000 to operate factory for dyeing

dress goods and textile fabrics. Incorporators are C. M. Riva, J. D. Huyvetters, J. Davison.

Imperial Dye Wood Co., Inc., Hackensack, N. J., has been incorporated with a capital of \$125,000 to deal in dyewoods. Incorporators are A. C. Hart, A. A. Hart, Hackensack; J. S. Baker, Garfield.

Independent Mines Smelting Co., Inc., Wilmington, Del., has been incorporated with a capital of \$1,500,000 to operate the Ward-Abel Parabola Oil Burning Smelter and other devices.

The Lima Metals Foundry Co., Lima, Pa., has been incorporated with a capital of \$15,000. Incorporators are M. G. Bush, S. Wiesenthal, John Thomas.

The Loomis-Sielaff Co., Cleveland, Ohio, has been incorporated with a capital of \$150,000 to manufacture and deal in metal products. Incorporators are J. G. Fose, M. M. Feidner, H. E. Davis, W. G. Radcliffe, R. E. Kouba.

McKesson & Robbins, Inc., Milbrook, N. Y., has been incorporated with a capital of \$200,000 to manufacture and deal in chemicals, etc. Incorporators are C. and J. McKesson, H. D. Robbins, 91 Fulton Street, New York.

Midland Carbon Co., Wilmington, Del., has been incorporated with a capital of \$500,000 to deal in carbon black products.

Henry-Miller Foundry Company, Cleveland, Ohio, has been incorporated with a capital of \$1,000,000. Incorporator, T. E. Henry.

Montague Gold Mining Co., New York, has been incorporated with a capital of \$1,000,000 to engage in mining of gold, silver, lead, copper and other ores. Incorporators are F. E. Reese, T. J. Buckley, J. Lecour, Jr., all of New York.

Moore Paper Mill Corp., Buffalo, N. Y., has been incorporated with a capital of \$50,000 to manufacture paper and box board. Incorporators are W. P. Goodenough, B. S. and C. G. Moore, 207 Anderson Place, Buffalo.

The National Process Co., Cleveland, Ohio, has been incorporated with a capital of \$10,000 to deal in paints. Incorporators are C. Taussig, H. K. Fox, E. H. Blywise, A. M. Wilber and M. Skala.

Neosho Zinc Co., New Haven, Conn., has been incorporated with a capital of \$150,000. Incorporators are A. M. Brown, W. A. Wright, G. M. Elger.

The Northwestern Leather Co., Boston, Mass., has been incorporated with a capital of \$1,500,000.

Odorless Fertilizer Mfg. Co., Wilmington, Del., has been incorporated with a capital of \$250,000 to manufacture fertilizers.

O-Zel-O Company, Fort Wayne, Ind., has been incorporated with a capital of \$15,000 to manufacture chemicals. Incorporators are J. Miller, H. W. Muller, H. C. Barnes.

The Pennsylvania Rubber Co., Jeannette, Pa., has been incorporated with a capital of \$2,000,000.

Rosslyn Steel & Cement Co., Washington, D. C., has been incorporated with a capital of \$15,000. Incorporators are C. T. Kingsbury, C. E. Dale, W. T. Galliber, B. C. Downey, F. L. Wagner, A. A. Hoehling.

Rubber Patchit Corp., Manhattan, has been incorporated with a capital of \$80,000 to manufacture rubber and leather products and vulcanizing materials. Incorporators are F. Rogers, E. Goldfarb, C. Bogardus, 140 Nassau Street, New York City.

Seneca Copper Corp., New York, has been incorporated with a capital of \$1,000,000 to mine, mill and smelt gold, silver, copper, lead, etc. Incorporators are K. A. Duffy, S. Kramer, F. G. Fischer, 15 Broad Street.

The Shaeffer Oil Corporation, Wilmington, Del., is incorporated with a capital of \$50,000.

Sivalls & Brysons, Inc., Portland, Me., has been incorporated with a capital of \$800,000 to manufacture and deal in oil tanks, water tanks, and gas tanks, to acquire oil and gas lands, etc.

South American Electric Smelting Co., New York, has been incorporated with a capital of \$50,000. Incorporators are J. B. Pruyn, C. W. Whittlesey, W. P. Martin, 17 Battery Place.

South Florida Sugar Co., Miami, Fla., has been incorporated with a capital of \$50,000 to refine sugar.

Southern Oil Co., Bettyville, N. Y., has been incorporated with a capital of \$30,000. Incorporators are C. Beach, R. G. Porter, W. Porter, L. Thomas, T. Blakey.

The Stanley Aniline Chemical Works, of Lockhaven, Pa., has increased its capital stock from \$1,000,000 to \$2,000,000.

Superior Steel Corporation, Richmond, Va., has been incorporated with a capital of \$17,000,000. Incorporators are M. Rogers, president, W. J. Smelser, treasurer, A. J. Christman, secretary.

Thunderbolt Copper Co. has been incorporated in Delaware with a capital of \$2,000,000 to conduct a general mining business. Incorporators are C. A. Cole, Hackensack, N. J.; Robert A. Van Voorhis, Jersey City; A. R. Oakley, Pearl River, N. Y.

Universal Leather Co., Trenton, N. J., has been incorporated with a capital of \$50,000 to manufacture leather goods. Incorporators are W. E. Gips, S. P. Friedman, New York; C. K. Kuttner, M. E. Ruback, Newark.

Utah-Idaho Sugar Co., Salt Lake City, Utah, has been incorporated with a capital of \$10,000,000. Incorporators are Joseph Smith and Horace G. Whitney.

Utilities Co., Inc., Ringling, Okla., has been incorporated with a capital of \$1,000,000 that is to establish natural gas and electric plants and develop water power sites in southern Oklahoma. Incorporators are P. C. Ekern, C. Dings, W. D. Potter.

The Whitfield Iron Co., Cleveland, Ohio, has been incorporated with a capital of \$10,000. Incorporators are F. S. McGowan, A. R. Manning, Jr., S. Chestnut, J. M. Harris, J. K. Lee.

Construction and Operation

Arizona

JEROME.—The United Verde Extension plant, the erection of a new smelter on the C. V. Honkins branch, near Cottonwood, A. G. McGregor, well known metallurgist, will superintend the construction. He recently visited Jerome with President James S. Douglas of the Extension Company to investigate the possibilities, and it is understood that work will be pushed as fast as possible on the new plant.

TUCSON.—Reported Mineral Hill Mining Co. plans erecting smelter and concentrator plant. Frederick Minard, engr., 111 Broadway, New York City.

California

LOS ANGELES.—The C. W. Hill Chemical Company has purchased a large site on San Pedro Street, between Sixth and Seventh Streets, on which a new plant will be erected.

MANTECA.—The contract has been awarded by the Spreckles Sugar Company to the Dyers Construction Company, of Cincinnati, Ohio, for the \$2,000,000 sugar plant which will be erect at Manteca. The same construction company is building a \$1,000,000 refinery for the Whitehall estates near Tracy.

NEWPORT.—It is expected that the Newport Glass Company, Inc., will shortly operate its factory here, as machinery and equipment are being installed.

OAKLAND.—The East Bay Foundry will erect a \$50,000 plant at Thirty-second and Chestnut Streets. The company will manufacture cast iron to be used in ship building.

RIVERSIDE.—The Sterns-Roger Manufacturing Company of Denver, which has established several sugar mills in Colorado and Idaho, is erecting a \$10,000,000 million-dollar plant in Riverside if 10,000 acres of lands can be signed up. The Riverside and Arlington Chambers of Commerce are working for the plant.

SAN FRANCISCO.—The National Carbon Company has applied for a permit to erect a four-story and basement brick mill and factory building at the northeast corner of Brannan and Eighth Streets, which will cost \$220,000.

SAN FRANCISCO.—The Pacific Tank & Pipe Company announces the completion of the first of the buildings of its new plant located on a 95-acre tract near the Melrose Station of the Southern Pacific in San Francisco Bay. The plant at present comprises four main buildings from 200 to 300 ft. long and 160 ft. wide. The main office of the company is at 316 Market Street, San Francisco. The officers of the company are E. C. Pitcher, president and general manager; R. Streets, vice-president; George W. Gerkins, chief engineer, and F. W. Schmitz, sales manager.

SAN FRANCISCO.—Plans were considered for the construction and operation of a co-operative paper mill at the meeting of The California Press Association in De-

cember. It was pointed out that at \$7 a hundred for newsprint in ton lots and \$6 a hundred in carload lots, it will soon be difficult for the small country paper to continue.

SAN PEDRO.—The Union Oil Company has purchased 231 acres on the McDonald ranch, between Wilmington and San Pedro, for a consideration said to be \$275,000. A new \$3,000,000 refinery will be erected on this site. The land purchased is some of the most valuable in the harbor district. It overlooks the West Basin tidelands and lies between the Wilmington Road and the garden line of the Pacific Electric. The plans of the company are said to include a new subdivision for homes of employees at the refinery.

SAN PEDRO.—The Universal Chemical Company, organized by Jas. J. Hagan and others, has purchased a site for a manufacturing plant. Various chemical compounds are to be produced in the new plant, the first of which will be oil emulsion for destroying pests that damage fruit trees.

Connecticut

STAMFORD.—The Stamford Rolling Mills Company is finishing its last war contract in the Springfield plant. All work of this nature has been finished at the Fairfield Avenue plant, and there is work enough on "peace" materials to keep the shops going a couple of years.

Florida

PENSACOLA.—The Southern Fertilizer and Oil Company has purchased a factory site, which is to conduct the manufacture of oil and fertilizer from menhaden fish. The site consists of 95 acres at Grassy Cove, across the bay from Pensacola.

Idaho

HARLEY.—The North Star mill of the Federal Mining & Smelting Company, which has been closed down for a short time in order to install some new machinery and make necessary adjustments, has resumed operations. The entire plant is now in full operation. The material being handled at present is tailings.

Kentucky

IRVINE.—Reported Schell Syndicate, Lexington, will build refinery here to cost between \$500,000 and \$800,000 and give employment to nearly 1000 men. Work will begin in spring.

LOUISVILLE.—The L. W. Rendering Company will build a \$15,000 rendering plant to produce bone fertilizer, grease, etc. They will need 4 tanks, one press, one boiler, one engine, one elevator, one dryer and one evaporator. Fred E. Hoertner is president, and Fred Ehrhart, Norton Bldg., is superintendent.

LOUISVILLE.—The Royal Dutch-Shell Syndicate is planning the construction of a refinery to cost \$500,000 at Irvine, Ky.

Louisiana

NEW ORLEANS.—The Freeport & Mexican Fuel Oil Corporation has broken ground for its new plant on the Story plantation. An office building is being erected which will be followed by stills and tanks.

Maryland

BALTIMORE.—The Standard Grease and Glue Company will erect a \$100,000 plant in the Curtis Bay District for the manufacture of glue, soap and tankage. George A. Dabing of Baltimore will be president of the new company.

BALTIMORE.—The Union Soap Company, 214 North Pearl Street, plans the erection of a \$1,000,000 soap factory at Seam's Park, to take care of large foreign and domestic orders. The company has been in business for forty years and has a large factory in Baltimore. The company was recently reorganized with Horatio Turner, president, to \$75,000. He is vice-president; J. C. Hardy, treasurer, and Nathaniel Ewing, general manager.

Massachusetts

SPRINGFIELD.—The Filleroid Company will increase its authorized capital stock from \$1,000,000 to \$17,500,000, in order to provide funds for new buildings, machinery and other equipment.

WESTFIELD.—The Mari Paper Corporation of New York has leased Crane's upper mill on the Crayville Road and will begin the manufacture of onion skin paper, for which there is a growing demand. The Mari Paper Co. of New York is president; J. B. White of New York, treasurer; F. J. Marshall and Elwood Brinker, both of Easton, Pa., will be in direct charge of manufacturing.

Michigan

MUSKEGON HEIGHTS.—The Campbell, Wyant, Cannon Foundry has leased the foundry buildings of the Racine Boat Works of Muskegon, and is preparing them for immediate use in the manufacture of an engine casting.

The Enterprise Foundry is completing a three-story foundry for the production of plumbing fittings and castings.

Missouri

ST. JOSEPH.—The St. Joseph Tanning Company is constructing two additional double dry tunnels which will give the plant a daily capacity of 600 to 700 sides of leather.

Montana

BIG FORK.—Work on the construction of a large paper mill to be built by the Glacier Pulp and Paper Company, a new concern organized by St. Paul and Minneapolis financiers, will begin soon. The mill will be erected in the vicinity of large timber tracts controlled by the promoters, and will be operated by W. P. Snow of Big Fork.

The main office of the concern, whose capital is \$100,000, will be in Minneapolis. The new company is backed by E. Warner of the McGill-Valley Paper Company of St. Paul, G. M. and L. S. Gillette and F. Jordan of Minneapolis, and W. P. Snow of Big Fork.

New Jersey

NEWARK.—A fire of undetermined origin partly destroyed one of the buildings of the Charles Cooper Chemical Company in South Street on Dec. 26. The building was used for the manufacture of colloid.

NEWARK.—The Union Smelting and Refining Company and the Eagle Smelting and Refining Company of New York, which recently consolidated, have purchased a plot of eleven acres on St. Charles Street, and the new plant will remove to New York to the new site. A series of modern fireproof buildings will be erected, the first of which will cost \$250,000. Their products consist of white metal of all kinds, type metal, solder, etc. The New York office is in the Woolworth Bldg.

New York

BUFFALO.—The additions which are being made to the plant of the Schoellkopf Aniline & Chemical Works are being rushed as fast as possible. A five-story research laboratory and office building 53 by 150 ft., has been started, and work will be commenced soon on a large power plant, an ice manufacturing plant and a machine shop as adjuncts to the new manufacturing plant, which is being erected on the site of the Cooper Company has charge of the construction work.

LOCKPORT.—New York capitalists have been negotiating for the purchase of the plant formerly occupied by the Lockport Paving Company. It will be used as a pulp mill.

Ohio

CLEVELAND.—The Valley Smelting Company will erect smelting plant at Bradley Rd. and B. & O. R. R.; cost about \$125,000. The company was recently organized with a capital of \$250,000. Thirteen acres have been leased at the above location and the plant will be used for smelting and refining waste materials. The officers are Joseph Sillman, president; Charles O. Patch, vice-president and treasurer; J. D. LeBel, assistant secretary and assistant treasurer, and Harrison B. McGraw, secretary.

CLEVELAND.—The Western Chemical Company, of which we had a short note in our last issue, is incorporated under the laws of Ohio with a capital of \$25,000. The company is taking over the plant known as the Fleming processes, methods supposed to be shorter and less costly. The plant here has been running on Prussian blue, and marketing it in bulk form the past three months, and nothing else will be made at this plant. About 100 lbs. per day is the output.

The Pittsburgh plant is being designed for larger output, 300 lbs. per day, but there the dried and ground product will be produced. Also such chemicals as enter the products, and also dyes. George H. Fleming is president and P. L. Summers general manager.

COLUMBUS.—The Winslow Glass Company has closed down its plant permanently and will seek another location, because its glass supply has been cut off. The company has been located on the South Side for several years and employs 300 men in making milk bottles.

TELFEX.—The Standard Oil Company will spend about \$50,000 on new buildings to be erected here within a few months.

YOUNGSTOWN.—The Linde Air Products Company has purchased a site here and will erect a plant for the manufacture of oxygen, etc. About 25 men will be employed at the start.

Pennsylvania

BELLEFOUNTE.—The Hyde City steel rolling mills have been bought by a syndicate of capitalists headed by Dr. C. F. Hendrix. This firm has just completed work remodeling and enlarging the plant at a cost of approximately a quarter of a million dollars. The price paid was about \$50,000.

The mills are located about two miles from Clearfield and have not been in operation for five or six years. It is the intention of the new owners to convert them into a rolling mill for nickel steel bars and titan bronze tubing. Every effort will be made to have the plant in shape to begin operations early in the spring.

CHARLESTON.—The Charleroi plant of Macbeth Evans Glass Company resumed operations the last week in December, using oil, for which installation was made, in the place of gas.

DONORA.—The powdered coal system being installed in the Donora plant of the U. S. Steel Corporation is progressing rapidly. An oil system is also being installed. The systems replace gas, the shortage of which caused the mills in this section to shut down.

MIDLAND.—Announcement has been made that the Crucible Steel Company will build a new foundry here at a cost of \$75,000.

JOHNSTOWN.—The Cambria Steel Company will spend \$70,000 on the erection of two new blast furnaces and a new plant to manufacture car wheels. Ground has been broken for the furnaces and work will start shortly on the wheel plant.

PHILADELPHIA.—S. B. & B. W. Fleisher are erecting a two-story dye-house to cost \$70,000 at Twenty-fifth and Dickinson Streets.

PHILADELPHIA.—The Empire Pulp and Paper Mills Company of Montreal, Canada, has taken over and will operate the old Swanson Bay Pulpwood Manufacturing Company's plant. This plant was erected a few years ago, but only ran a short time. The new management plans to turn out 300 tons of pulp daily.

PHILADELPHIA.—The new firm of Monroe, Lederer & Taussig, which was formed by parties formerly with the Thompson Wood Finishing Company, will manufacture specialty paints and enamels for dipping, brushing, spraying for furniture manufacturers and allied trades. The new plant was expected to be in operation at the first of the year.

PORT ALLEGANY.—Dr. V. Mott Pierce, head of the Pierce Glass Company of Hamburg, has purchased the large plant built by the Glenn Glass Company at Port Allegany, Pa., which he expects to operate early in 1917.

SOUTH BETHLEHEM.—The Bethlehem Steel Company announced on Dec. 29 that work would start on a new hot and cold foundry with a capacity of 150,000 tons per annum, to be located at the eastern end of the Saucon plant. The cost of the building and equipment will be about \$750,000.

Utah

GARFIELD.—The American Smelting & Refining Company's sulphuric acid plant, which is to make sulphuric acid from the smelter gases, will be put in operation in a short time with an initial capacity of 100 tons per day.

MORONI.—The sugar factory of the People's Sugar Company is now under way. The site is situated one and a half miles south of Moroni in northern Sacate County on the Denver & Rio Grande Road. It is in the center of a large beet growing area, and is the first sugar factory to be erected in this district.

SALT LAKE CITY.—The Knight sugar factory at Raymond, Canada, is being dismantled by engineers of the Lynch-Cannon Eng. Co. of Utah and the Cannon-Swanson Sugar Mch'g Co. of Chicago, and will be shipped to Cache County, Utah, where several sites have been offered for its establishment.

SYRACUSE.—George M. Cannon, a real estate man of Salt Lake City, has been making considerable study as to the advisability of erecting a beet sugar factory in Davis County near Syracuse.

Washington

NORTH YAKIMA.—The Utah-Idaho Sugar Company is planning work on a \$1,000,000 plant in North Yakima. About

50 tons of lime per day will be needed during the manufacturing season and Mr. Horne, resident agent, has been receiving bids for this material. The silica content must not be over 2 per cent.

SEATTLE.—The American Nitrogen Products Company, C. P. Grant, manager, which has obtained the rights to use the patented electric furnace of F. H. A. Wielgowski, is putting up a temporary plant of 300 kw., capacity capable of expansion to 6000 kw., for the fixation of atmospheric nitrogen. Mr. Wielgowski is engineer in charge. It is understood that the company is seeking capital.

SEATTLE.—The president of a company owning a brewery in South Seattle announced recently that part of the plant would be equipped for manufacture of industrial alcohol, following the suggestion of an Eastern manufacturer of automobiles. The alcohol plant will be in operation in a few weeks.

STUMNER.—The Northern Board & Paper Mills will erect a 35 x 100-ft. addition to take care of increased demand. The present output of paper board is 28½ tons per day.

West Virginia

WHEELING.—Contracts are being let for work on an \$8,000,000 sheet steel plant to be erected by the Whitaker-Glessner Co. at Beech Bottom, near here.

Wyoming

BASIN.—John C. Roberts, manager of the Consumers Oil & Gas Company of Billings, Mont., has announced that his company will start construction in the spring of a large oil refinery at Basin with a capacity of 1000 barrels per day.

Canada

CHICOUTIMI, QUE.—The Chicoutimi Pulp Company will move in addition to its plant here and increase its output from 30,000 to 130,000 tons of pulp per year.

COBALT, ONT.—The Davidson Gold Mines, Ltd., has completed negotiations with the London financial house for the issue of a large block of treasury shares to provide funds for the erection of a large mill.

QUATSINO SOUND, ONT.—The Colonial Pulp & Paper Mills, Ltd., will build here a sublimé plant to have a daily capacity of 120 tons. The first unit will have a daily capacity of 60 tons. The installation will be completed in about a year.

VANCOUVER, B. C.—The American Consol in British Columbia has sent to the Board of Foreign and Domestic Commerce the following note in regard to the purchase of a smelter by American capitalists:

"The Ladysmith smelter, formerly operated by the Tyee Copper Company, an English concern, has been purchased by American capitalists, and as soon as extensions and improvements involving an outlay of \$100,000 can be made the plant will be put into operation.

"Efforts have been made for some time by local organizations interested in the development of mines on Vancouver Island to induce the Provincial Government to take steps for the opening of the Ladysmith smelter. With its extensions it will soon be in full operation and will employ more than 100 men. Facilities provided by the extensions will enable it to turn out blister copper, whereas formerly it could produce only copper matte. Mine operations on Vancouver Island have been sending their ores to the smelter at Tacoma, Wash. for treatment, and with the operation of the Ladysmith smelter the necessity for this will be obviated.

"It is stated that the Tacoma smelter is very busy, and if it is offered more business it can handle the mine output on Vancouver Island would find their smelter facilities curtailed without some arrangement on Vancouver Island.

"The new enterprise is to make the plant thoroughly modern and install converters. Blister copper, instead of being sent out of the Province, probably will be treated by large electrolytic refineries. The capacity of the Ladysmith smelter is 500 tons, but will be greatly increased."

ST. JOHN, N. B.—The Partington Pulp & Paper Co. (Ltd.), of St. John, New Brunswick, has sold its mill and timberlands to interests in the United States for about \$3,000,000. The purchase includes 372,000 acres of spruce and fir wood and 1,000,000 ft. of hardwood. The output of timberland comprises nearly 30,000,000 cords of wood. The purchasers are incorporating a new company, which proposes to start an early start to increase its output of the Partington sulphite mill from 60 to 80 tons of bleached sulphite pulp daily. It is understood that the principal object of the purchasers was the acquisition of the timberlands.

Manufacturers' Notes

RUST PREVENTIVE PAINTS.—The Harrissburg Chemical and Paint Company, Inc., 917 Hemlock Street, Harrisburg, Pa., which recently enlarged its plant is specializing on Rust Prevento Oil, Rust Prevento Paints and Damp Prevento Concrete Dressing. These products have been the subject of various tests in actual service, and have proven satisfactory preventives.

The oil can be applied either upon new metal or metal that is already corroded.

Tests have been made during the past six years, under all conditions, which have given a wide range of the various ways in which it can be used, not only upon iron and steel, but upon tin, nickel plating, etc.

PULVERIZED COAL EQUIPMENT.—The Fuller Engineering Co., Allentown, Pa., have contract for pulverized coal equipment for American Steel and Wire Co., Donora Steel Works, Donora, Pa., in connection with eight 60-ton open-hearth furnaces, for pulverized coal equipment for heating furnaces of the American Works of the American Steel and Wire Co., at Cleveland, Ohio, and pulverized coal equipment for two open-hearth furnaces in No. 1 Lehigh plant of the Bethlehem Steel Co., South Bethlehem.

SOUTHERN STATES ENDORSE MUSCLE SHOALS FOR GOVERNMENT NITRATE PLANT.—The Southern Congress unanimously endorsed resolutions on Dec. 13 endorsing Muscle Shoals as the best available site for the government nitrate plant. The committee's recommendation was made after the endorsement of the South for the Muscle Shoals location. Muscle Shoals has been described in this journal in connection with the West Virginia of the American Cyanamid Co., to build a factory there and supply the government with all requirements of nitric acid. It is the only place in the South where 120,000 ft. of pulp have been developed 24 hours a day. It is the only Southern location that has received any consideration from the War Department engineers.

PUBLISHERS IN TEXAS AND LOUISIANA CONSIDERING ESTABLISHMENT OF PAPER MILLS.—In many parts of the country publishers have held meetings to consider the advisability of establishing cooperative paper mills, to counteract the high cost of paper. In California, West Virginia and other states the movement has been on foot for some time. The latest section to take up the question includes Texas and Louisiana. After the holidays there were over a meeting of the publishers of Texas and Louisiana was to be held in Beaumont to discuss the feasibility of the plan and to gather authentic information. The value of gulf coast products for making print paper. Sweet gum wood is mentioned as one of the valuable raw materials from which paper can be made.

SOUTHERN TURPENTINE PRODUCERS ORGANIZE.—Turpentine manufacturing interests of Louisiana, Mississippi and Texas met in New Orleans Dec. 20 and decided to organize the turpentine producers association, to be operated on a similar basis to that of the Southern Pine Association.

Charles F. Spoh of Washington called the conference. H. H. Gordon, president of the Independent Naval Stores Company of Lake Charles, La., presided. West Virginia and other states the movement has been on foot for some time. The latest section to take up the question includes Texas and Louisiana. After the holidays there were over a meeting of the publishers of Texas and Louisiana was to be held in Beaumont to discuss the feasibility of the plan and to gather authentic information. The value of gulf coast products for making print paper. Sweet gum wood is mentioned as one of the valuable raw materials from which paper can be made.

Among prominent naval stores producers present were: J. N. Corbett, Fullerton, La.; E. M. Pringle, Glen Mire, La.; V. G. Phillips, Provencal, La.; W. A. Hood, Pine Bar, La.

PLANT FORCED TO LEAVE COLUMBUS.—The Winslow Glass Company, Ohio, which employs 300 men in making milk bottles has been forced to shut down its plant and move its operation owing to the shutting off of its gas supply.

SHORTAGE OF NATURAL GAS IN INDIANA.—The blowing of colored glass will be discontinued at the plant of the Johnston Window Glass Company, Hartford, Ind., on account of the unavailability of the natural gas supply, the only fuel which can be used to advantage in the manufacture of this article. About fifty employees will be thrown out of work in this line by the decision of the company.

ENGLAND WILL BUILD FOR LARGE CHEMICAL TRADE IN MEXICAN WARE.—That England will make a strong endeavor to secure a big export business in chemicals after the war is the belief of those familiar with conditions and developments in that country. It is estimated that the free-trade policy will be abandoned as duties are considered essential for the building up of the chemical industries. There has been a remarkable development in chemical manufacturing in England since the war began, and many factories which are supplying war needs can be converted to making various products.

1916 GREATEST EXPORT YEAR.—Manufactures were exported from the United States in 1916 to a value greater than the value ever exported by any country. It is estimated that the year's total was considerably in excess of \$3,000,000,000. The highest export record ever made by Great Britain was \$2,012,000,000 in 1913, the year immediately preceding the war. Prior to the war, the United States held third rank. In 1914 our exports amounted to \$974,000,000 and in 1915 to \$1,784,000,000. A statement of the National City Bank is as follows:

"The growth in exports since the beginning of the war is, of course, due in a considerable degree to the demands for strictly war material, explosives alone being for 1916 approximately \$675,000,000. Shell tubes for the manufacture of shells \$225,000,000; while in many other articles, such as automobiles and various articles of iron and steel there is a large increase, although just what proportion of the growth is due to the demands of the war can only be estimated. Of iron and steel manufactures of all kinds the exports of the full year show a total of approximately \$400,000,000 against \$200,000,000 in 1914."

In the view of the bank, the experiences of the year just ended demonstrated the ability of the manufacturers of the United States to supply in larger proportion of the manufactures entering world commerce than they have in the past, since the total value of the manufactures which were exported in 1916 was approximately 40 per cent of the total manufactures entering international trade in normal years as against approximately 15 per cent which this country's manufacturers supplied in the year just preceding the war. The report showed that prior to the war the percentage which manufactures formed of the domestic exports of Great Britain was 79 per cent, Germany 67 per cent, France 58 per cent, and of the United States 47 per cent. Manufactures formed 15 per cent of American domestic exports in 1880, 21 per cent in 1890, 35 per cent in 1900, 40 per cent in 1910, 49 per cent in 1913 and approximately 66 per cent in 1916.

MEETING OF TUNGSTEN PRODUCERS.—At a meeting of a special committee of tungsten producers of this State, appointed by Frederick Wells, chairman, the following members, Harold Boericke, Primos N. & M. Co., Boulder; J. A. McCormick, Vasco Mining Company, Boulder; Robert M. Kennerly, Colorado Tungsten Company, Denver; J. G. Clark, Boulder Tungsten Produce Co., Boulder; William Leach, Platt Rogers Mfg. Co., Boulder; Forbes Rickard, Rugged Tool Co., Denver; Platt Rogers, Rogers Patent, Denver; Horace Holmes, Luckie 2 Mfg. Co., Boulder; Geo. W. Teal, Tungsten Metals Co., Boulder; Wm. Cowley, Long Chance Mfg. Co., Nederland; Nelson Franklin, Tungsten Ores Co., Rollinsville; N. H. Brown, Mojave-Boulder Tungsten Mfg. Co., Sugar Creek. It was decided to call a meeting of the tungsten producers of the United States to convene during the annual meeting of the Colorado Metal Mining Association, to be held in Denver Jan. 9, 10 and 11, 1917. This meeting was for the purpose of calling a conference of the tungsten producers of the country to formulate a plan for concerted action in all matters affecting the industry and especially in an effort to secure as early as possible favorable action on the part of the proposed tariff Commission in behalf of a duty on tungsten and the products thereof.

SALES CONVENTION OF THE KENNEDY VALVE MANUFACTURING COMPANY.—The sales force of The Kennedy Valve Manufacturing Co. convened at its plant in Elmira, N. Y., on Dec. 14 and 15. A most interesting and profitable convention was held. It was the first time that many of the salesmen had met the new sales manager, Mr. J. L. Peden. On the morning of the first day the entire company of salesmen and managers made a tour of inspection through the company's plant, which is located on a plot covering twenty acres. Numerous arguments were heard pro and con, and in the evening a dinner was given at the Country Club in Elmira. The meeting was unanimously voted to have been the most successful ever

held by The Kennedy Valve Manufacturing Co., and reflected great credit on the several executives who had it in charge.

FRENCH CONCERN WANTS CATALOGS.—Mr. Jacques Vieyra, 24 Rue de Lubeck, Paris, France, is desirous of receiving catalogs and literature on electric motors and supplies (not motors or generators), laboratory supplies for industrial, chemical and metallurgical work, with a view to taking up the importation and the sale of the portion of the goods mentioned throughout France and her colonies.

FOREIGN TRADE OPPORTUNITIES.—The following opportunities for foreign trade have appeared in recent Commerce Reports:

23.382.—A firm in Spain wishes to represent American manufacturers and exporters of dyestuffs used in coloring cotton, woolen and silk textiles. The firm also desires to purchase on its own account. Cash will be paid against documents. Quotations should be made c. i. f. destination. Correspondence may be in English. Reference.

23.385.—A man in Spain wishes to purchase dyestuffs for the textile industry. Quotations should be made f. o. b. New York or c. i. f. destination. Correspondence may be in English. Reference.

23.387.—A man in Venezuela wishes to purchase machinery for making glue, as a by-product of a tannery. Machines are desired with a capacity of about 275 lb. per day. Correspondence is preferred in Spanish, but English is all right.

23.394.—A man in the British West Indies desires to be placed in communication with American manufacturers of small power steam mills and fiber vessels of cut. capacity.

23.396.—A business man in Switzerland would like to purchase several tank cars, with a capacity of 4000 to 6000 gal. for oils, petroleum, etc. The cars are to be constructed in compliance with the specifications of the Swiss Federal Railways. Quotations should be made c. i. f. European port. Cash will be paid against documents. Correspondence should be in French or German. Reference.

23.401.—A company in India wishes to receive catalogs and full information from American manufacturers of modern aerated water plants. Quotations are desired c. i. f. foreign port. Correspondence may be in English. Reference.

23.403.—A man in Spain is desirous of representing American manufacturers and exporters of varnishes, colors and drugs. Correspondence may be in English. Reference.

23.424.—An engineer in Norway desires to secure a sole agency for the sale of leather and materials of all kinds for use by engineers and builders. Quotations should be made f. o. b. American port or c. i. f. destination. Correspondence may be in English. Reference.

LEATHER TRADE.—The Swiss Government, according to the U. S. Consul at Berne, has undertaken the protection of the leather supply of the country, and its first step has been to place the country's shoe factories under the control of the Department of Agriculture and the War Office, to fix maximum prices for the shoe and leather trade and issue directions to the tanners regarding the preparation of the hides and skins. Licenses hereafter issued by the Swiss Military Department will enable business men to buy the skins and hides of animal slaughter at prices and conditions fixed by the government, but will insure deliveries of stocks held by tanners, as the law provides that stocks cannot be withheld from buyers with licenses. Only goods that cannot be used in the country may be exported, according to the provisions of the new law. The maximum prices do not affect running contracts.

MEETING OF OBEX LABORATORIES.—A meeting of the stockholders of The Obex Laboratories Co. was held at the offices of the company, Marietta, Ohio, on Tuesday, Jan. 2. Mr. G. A. Vallee, president of the company, read a report summarizing the year's work, which report included a high and successful year. It was voted to change the name of the company to "The Obex Company," and the capital stock was increased from \$200,000 to \$400,000. A new board of seven directors was elected, consisting of the following members: Judge E. B. Follett, R. M. Noll, J. H. McCoy, C. J. La Vallee, C. E. LaVallee, G. A. Vallee, all of Marietta, and A. Alexander of New York City. All of the products of the company are sold exclusively through the National Gum & Mfg. Co.

ANNUAL CONVENTION OF VANADIUM-ALLOYS CO.—On January 3, 1917, at the Pittsburgh Athletic Association occurred the Annual Convention and Banquet of the

Sales Representatives of the Vanadium-Alloys Steel Company, Pittsburgh, Pa., which manufacture high speed, chromium alloy tool steel, and some very interesting topics were thoroughly discussed, the most prominent being a paper on "Crucible Tool Steel," read by Roy C. McKenna, president of the company. The following day a trip to the mills at Latrobe, Pa., was enjoyed by all of the representatives, after which the salesmen returned to their respective posts in the United States and Canada.

Manufacturers' Catalogs

HUMIDITY AND TEMPERATURE REGULATING DEVICES.—Bulletin No. 102, containing 48 pages of description and illustrations of controlling devices to meet all commercial requirements has just been issued by the Carrier Engineering Corporation, 39 Cortlandt Street, New York. The introductory pages explain how a system of control is dependent upon various factors, chief among which are the number and sizes of rooms, their contents, arrangement of machinery, sources of heat and moisture, direction of air currents and the exact humidifying, dehumidifying, heating, cooling and drying or combination of these to be accomplished.

THE VANADIUM-ALLOYS STEEL COMPANY.—Pittsburgh, Pa., has issued a folder descriptive of Vasco-Marvel, a semi-high-speed steel. This folder contains much information of interest, together with the High Speed Steel Standard Classification of Extras adopted July 22, 1915.

Other New Publications

GOLD, SILVER, COPPER, LEAD AND ZINC IN IDAHO AND WASHINGTON IN 1915. By C. N. Gerry. U. S. Geological Survey Report, Part of Mineral Resources of U. S. for 1915.

IRON, COBALT AND ORES IN 1914 AND 1915. By J. P. Dunlop. U. S. Geological Survey Report, Mineral Resources of U. S.

GOLD, SILVER, COPPER, LEAD AND ZINC IN NEVADA IN 1915. By V. C. Heikes. U. S. Geological Survey Report, Mineral Resources of U. S.

COKE IN 1915. By C. E. Leshner. U. S. Geological Survey Report, Part of mineral resources of U. S. for 1915.

PETROLEUM IN 1915. By John D. Northrup. U. S. Geological Survey Report, Part of Mineral Resources of the U. S.

MOLYBDENUM: ITS ORES AND THEIR CONCENTRATION, with a Discussion of Markets, Prices, and Uses, by Frederick W. Horton. Bureau of Mines Bulletin 111.

MAGNESITE IN 1915. By Charles G. Yale. U. S. Geological Survey Report, Published December 1916. Part of Mineral Resources of U. S.

COPPER IN 1915. General report. By B. S. Butler. U. S. Geological Survey Report, Published December 20, 1916. Part of Mineral Resources of U. S.

MAGNESIUM IN 1915. By Frank L. Hess. U. S. Geological Survey Report, Published December 21, 1916. Part of Mineral Resources of U. S.

CLAY-WORKING INDUSTRIES AND BRICK-MAKING OPERATIONS IN THE LARGER CITIES IN 1915. By Jefferson Middleton. U. S. Geological Survey Report, Published December 22, 1916. Part of Mineral Resources of U. S.

BORAX IN 1915. By Charles G. Yale. U. S. Geological Survey Report, Published December 18, 1916. Part of Mineral Resources of U. S.

COAL IN 1915. PART A. PRODUCTION. By C. E. Leshner. U. S. Geological Survey Report, Published December 16, 1916. Part of Mineral Resources of U. S.

NATURAL GAS IN 1915. By John D. Northrup. U. S. Geological Survey Report, Published December 23, 1916. Part of Mineral Resources of U. S.

COAL IN 1915. PART B. DISTRIBUTION AND CONSUMPTION. By C. E. Leshner. U. S. Geological Survey Report, Published December 23, 1916. Part of Mineral Resources of U. S.

OPERATING DETAILS OF GAS PRODUCERS. By R. H. Fernald. Bureau of Mines Bulletin 108.

Mr. Fernald discusses the producer-gas plant situation as it exists in the country to-day and also compares the producer-gas plant with the steam turbine.

Although, as is pointed out, a great deal of indefiniteness exists regarding many of the operating details, and few, if any, cost data are available, it is believed that in this bulletin is given the information is presented to provoke widespread discussion on the part of those interested in this form of power.

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Contents for February 1, 1917

EDITORIAL:

The Railroad Congestion	121
The Rat Problem	122
Changes in Steel Demand	122
The Engineer in Americanization	123

READERS' VIEWS AND COMMENTS:

Determination of Phosphorus in High-Speed Steels. By Edward A. Kraus	124
A Story. By J. W. B.	124
Legal Status of Flotation Processes. By A. B. C.	124
Chemical Credits. By Ellwood Hendrick	126
Coming Meetings and Events	127
Program of New York Meeting of American Institute of Min- ing Engineers	127
Smelter, Smoke and Fume Problem	128
Current News and Notes	128
The Calculation of Lead Blast Furnace Charges—II. By Boyd Dudley, Jr.	129
The Recovery of Benzol from Gas. By F. W. Sperr, Jr.	135
Presentation of the Perkin Medal to Ernst Twitchell. Papers by C. F. Chandler, Ernst Twitchell, A. C. Langmuir, Martin Hill Ittner and Herman B. Schmidt.	141
Metallurgy of Cadmium Raw Materials, Technique and Eco- nomics. By Franz Juretzka. Translated by Oliver C. Balston	146
New York Meeting of American Institute of Chemical Engi- neers	149
The Human Side of the Development of Chemical Industry. By G. W. Thompson	149
Volatility of Gold of High Temperatures in Atmospheres of Air and Other Gases. By W. Mostowitsch and W. Plet- neff	153
Development in Chemical Engineering Equipment. By H. D. Miles	154
A New Electric Zinc Smelting Process	158
A Method of Determining the Density of Fine Gases. By Jas. Alex. Smith	160

SYNOPSIS OF RECENT METALLURGICAL AND CHEMICAL LITERA- TURE	161
RECENT METALLURGICAL AND CHEMICAL PATENTS	163
Oxygen Manufacturing Company Expanding Its Operations ..	164
An Apparatus for Locating Thermal Transformation Points ..	165
A Device for Automatically Testing Liquids	166
PERSONAL	166
OBITUARY	167
BOOK REVIEWS	167
Current Market Reports—Iron and Steel Market, Non-Ferrous Metal Market and Chemical Market	167
Industrial, Financial, Construction and Manufacturers' Notes ..	171

The Railroad Congestion

The railroads are found to be quite incapable of handling all the freight offered them, and the steel industry suffers more than other industries. Shipments are greatly interfered with as to both volume and celerity, and production is measurably reduced. It is natural that the steel industry should suffer most, for there are no really large industries that involve the movement of so much material in proportion to the finished output. The number of ton-miles of freight involved in placing a ton of commercial steel at its point of ultimate use is enormous. About four-fifths of the iron ore is moved a great distance, fully two tons of ore to a ton of finished product, while most of the coke is moved a considerable distance, about ton for ton. Then there is coal and limestone, which does not appear in the finished product, besides slag that must be carried away. Between works there is considerable movement of pig iron and scrap, as well as of partly finished material. Thus the railroads are called upon to do a great deal of work, and the least insufficiency in performance is necessarily reflected in the operation of the industry.

The efficiency of the railroad depends upon much the same items as does the efficiency of a steel mill. The blooming mill, for instance, must be supplied with ample power. The engine must be capable of delivering enormous power at slow speeds for the first pass of the ingot, like a locomotive starting a train, and it must be capable of high speeds for the final pass, just like the locomotive when it has a clear track before it. If either engine is inadequate for either the slow or the fast service the total capacity of the unit is reduced. There must be storage facilities for ingots and blooms, just as the railroad must have storage room at its terminals, and there must be a sufficient number of passes in the blooming mill as there must be a sufficient number of tracks on the railroad.

There is another line of analogy between the rolling mill and the railroad. Given certain specifications the rolling mill can produce a very large tonnage, and the customers who have filed those specifications are well satisfied. Other customers, the filling of whose specifications requires roll changes, sometimes have occasion to wait. It is related of a relatively small western road that while some of the shippers depending upon it are greatly incommoded the road is carrying the record tonnage of its history. At one junction point it is embargoed except as to train loads. The connecting line will accept train loads and nothing else, and it chances that this road is able to make up many such train loads, hence its large tonnage while many customers are suffering.

The experience of the steel mills in the past two or three weeks has shown conclusively that the weak element in the railroad equipment is the motive power. For a time car shortage was blamed, the mills not receiving sufficient empty cars. That could have been due to a variety of causes, but of late the supplies of cars at mills have increased but the facility of movement has decreased. When the cars are loaded the railroads are unable to carry all of them away, and insufficiency of motive power is now clearly indicated. It is particularly unfortunate that the difficulty should be at this point, for the reason that under the severe duties imposed the efficiency of the motive power decreases week by week, locomotives requiring repairs for which their time cannot be spared. Terminals and sidings do not wear out, nor do cars in any short period of time. Thus there is little prospect of material relief in the railroad situation in the near future.

No considerable number of new locomotives is to be delivered to the railroads in the near future. Statistics recently gathered by the *Railway Age Gazette* indicate this. It may be assumed that the locomotive shops had scarcely any orders on their books Jan. 1, 1915. In the two years since that date the domestic and export locomotives booked by shops in the United States and Canada totaled 7397, while the locomotives produced totaled 6160, leaving 1237 on books at the beginning of this year, and probably more than half of these were for export. As there are in service in the United States about 65,000 locomotives there should be thousands added rather than hundreds.

The Rat Problem

Somebody guesses that a rat census of the United States would show as large a number as that of the population; that it would be above the hundred million mark. Like flies and mosquitoes, they have not a single valuable quality and they not only carry disease but they consume vast quantities of human food. They are bearers of the contagion of bubonic plague and leprosy and they are the enemies of mankind. Indiana and Michigan offer pecuniary inducements to their citizens to kill rats. On Feb. 12 there is to be held a dead rat fair in Boston with prizes offered at the several "sanitary yards" of the city to citizens who excel in the de-ratting, the un-ratting, or ent-ratting art; even the word has not been coined yet. The prizes are to be given by the Women's Municipal League and Mayor Curley gives encouragement to the effort.

All this is good, but it is likely to be sporadic in Boston and local in Indiana and Michigan. The great nation of rats, engaged in seeking life, liberty and the pursuit of happiness need not despair of the wrath of Boston or the legislation of the Middle West, provided they understand human nature, and with this they seem to be tolerably familiar. They are not so closely attached to their homes as are their feline enemies and on slight provocation they move. They travel easily by night, they have no loads of furniture

to carry with them, and the proprieties of sanitation do not interest them at all, save as things to be avoided. We do not think the death-knell of the species has sounded yet.

Now let us see if we may not find a profitable use for dead rats, in which the problem of immediate transportation is not involved. If we make of rat-killing a profitable sport in which everyone so inclined may engage at his leisure, the death-curve among the species may grow sharper than the curve of increase. Of course, it takes a chemist to solve the riddle; in this instance a leather chemist. The solution is, tan their hides. Animals with thick fur have poor hides, those with thin fur produce durable, strong leather. The rat has thin fur. They are large enough for gloves, mitts, soles, inlays, buttons and a vast number of other uses to which leather is put. The skins are worth 10 cents each, easily. They may be salted down and nailed up against a barn door and dried. They will keep indefinitely. When a farmer has a couple of dozen set aside they may be carried to town in a basket and disposed of to the postmaster for \$2.40. Five thousand skins a day would keep a tannery running profitably. The government would increase its parcel post receipts and do a grand service in that thing for which we lament we haven't the word yet—ent-ratting, let's call it. It would be an act of altruism to buy and wear or use articles made of ratskin, which we offer as the cheapest and easiest method of achieving virtue that has been offered in a long time. If ratskins grew scarce and the tannery could operate only on part time, the price would go up and they would become fashionable. The tariff commission would then have an interesting problem to solve whether foreign ratskins should be admitted free of duty or not. When the problem reached Congress it would serve the excellent purpose of breaking down party lines—a consummation always devoutly to be wished for.

As for the cat and rat farm wretch who would raise these animals in captivity, selling the skins and feeding the carcasses of cats to rats and rats to cats, it should not only be discouraged but legally prohibited; strengthily undersaid. Rat catching must remain a sport.

Changes in Steel Demand

It will be recalled that 1906, one of the best years the steel trade has passed through, with respect to there being a sustained and heavy demand, was a year of much new construction. The railroads were all active in laying new track and in adding to their rolling stock. There was much new construction in bridges and buildings. Conditions since the war started have been altogether different. New construction has been light, except where stimulated by the existence of war orders, while there have been large exports of steel. There are as yet no statistics of steel production last year, but it is of interest to compare the distribution of steel production, as to the various finished com-

modities in 1906 and 1915, as shown by the following table:

Percentages of Iron and Steel Production

	1906	1915
Rails	20.4	9.0
Shapes	10.8	9.9
Plates	12.9	12.4
Sheets	5.5	8.0
Tin plate	2.9	4.5
Wire rods	9.5	12.6
Bars	20.2	16.9
Skelp	7.8	9.4
Hoops	.9	1.2
Bands and cotton ties	2.1	1.8
Export billets, etc.	1.0	2.3
Miscellaneous	6.0	12.0
	100.0	100.0

The production of rolled material increased from 19,588,468 gross tons in 1906 to 24,392,924 tons in 1915, or by 25 per cent. As the proportion of rails was decreased by more than one-half, the actual tonnage decreased. Railroad buying in general decreased in somewhat the same manner. Another large decrease was that in bars, while structural shapes showed a small decrease. There was a slight decrease in the proportion of plates, and as shipbuilding was particularly active in 1915 it may be assumed that the use of plates in structural work underwent a proportionate decrease, as was the case with shapes.

The increase in the proportion of sheets, tin plates and hoops is not to be ascribed to the war but is rather a part of a continual expansion in the use of these light products, which are constantly being employed in new uses. All studies of steel production statistics indicate that year by year steel is entering more into the common everyday use of the people at large. There was a time, in the decade of the eighteen-eighties, when the railroads were credited with consuming fully half the iron and steel produced in the country. As the theoretical per capita consumption increases it becomes more and more a real per capita consumption and not merely an average.

The Engineer in Americanization

Last week Mr. and Mrs. Vincent Astor and the Immigration Committee of the Chamber of Commerce of the United States gave a dinner at the Astor home "to the engineers of America," the subject of after-dinner discussion being the part of the engineer in industrial Americanization. There is no more important subject for engineers to discuss at present, but the many digressions of a few of the speakers on that occasion clearly showed that the recognition of the real meaning of "industrial Americanization" is not yet universal even among prominent engineers.

The future of the industries of this country depends to a large extent on the immigrant. No detailed statistics is needed here to show that while the invention and installation of labor-saving machinery has made rapid progress, the need for more and more men has neverthe-

less simultaneously progressed at an increasing rate. Nor is the number all that is needed. We have emphasized before in these columns that the thousands and thousands of immigrants now working in contractors' gangs and unable to speak English represent an immense untouched industrial asset. Every one of them has a history and many of them have a trade and are masters at their trade, but so far we have been unable to make right use of them.

The industries owe to the immigrant laborer more than a full dinner pail. What is his due in the widest sense may be summed up in the term "Americanization." Above all he must learn English, since personal contact is everything. But the conditions of work and the conditions of living also count. The slums must go. There is something radically wrong with industrial works that cause slums to come into being or to be maintained. But the first step—the step that counts and that is most difficult—is to teach the immigrant English. How can it be done?

What really wonderful work is possible along these lines has been shown in the past nine or ten years by the International Committee of Young Men's Christian Associations (Industrial Department) which has enlisted 4500 college men who are weekly reaching 100,000 working men and boys in volunteer service. These young college men from 250 colleges are teaching English to foreigners, instruction classes of American workmen, etc. What this means to the immigrant is clear; it is his first chance to come into sympathetic contact with Americans.

But it is even more remarkable what this work means to the young college man. This work reacts on him. To sow love is to harvest love. It means that a thousand men are graduating from our American colleges each year after having secured in this way a vision of their service opportunities and responsibilities and some experience in handling men with intelligence and sympathy.

Thus the Americanization movement is bound to react on the Americans. If it was emphasized by one speaker at the Astor dinner that the first thing to do is to Americanize the Americans, the work with the immigrant is one means of changing Americans into better Americans, of creating a broader vision of the responsibilities of service to mankind. To quote another speaker it is well enough to urge universal military service, but should we not emphasize "service" rather than "military"? The Americanization movement needs the help of everyone. Americanization should not be left so much to the individual employer's paternalism, but should rather become a legitimate function of every great industrial organization. And because this is so it needs the help of the engineer with his scientific methods of organizing.

The famous Astor home at 840 Fifth Avenue has seen many a brilliant fashionable function of ultra-fashionable society, but it has never been filled more freely with the true American spirit than at these dinners tendered by its present masters in the furtherance of industrial Americanization.

Readers' Views and Comments

Determination of Phosphorus in High-Speed Steels

To the Editor of Metallurgical & Chemical Engineering

Sir: The following modification of the present methods for the determination of phosphorus in high-speed steels has been found by the writer to be accurate and rapid, excellent results being procured on government standards containing various amounts of tungsten and vanadium.

Dissolve two grams of the sample in 1-3 aqua regia, and when the solution is boiling quietly add a few crystals of potassium chlorate. Evaporate to about 20 c.c. Then remove from hot plate, add 40 c.c. of water, cool under tap and filter, washing twice with 1-1 HCl. Next evaporate the solution to the "basic ring." Again remove from the plate, wash down sides of beaker with about 25 c.c. of water, cool and filter. Transfer solution to Erlenmeyer flask and after neutralizing with 10 c.c. of ammonia and adding 15 c.c. nitric acid, precipitate immediately with molybdate solution. If vanadium is present, reduce with 5 c.c. of 3 per cent sulphurous acid just before adding the molybdate. Allow solution to stand 45 minutes after thoroughly shaking. Then filter, and determine phosphorus by titration with standard acid and alkali solutions.

EDWARD C. KRAUS.

Laboratory Atlas Steel Co.,
Punkirk, N. Y.

A Story

Anent the Editorial on Niagara Power Crisis in "Metallurgical & Chemical Engineering," Dec. 1, 1916

To the Editor of Metallurgical & Chemical Engineering

SIR:—Once upon a time there was a farmer who had a dairy ranch. He was not what might be called a scientific farmer, rather one governed by the rule of thumb. By dint of hard-earned experience he had found that his stock of cows flourished if he gave them a mixed diet. They grew sleek under it and delivered rich milk.

Part of the mixed diet which he offered them he raised himself on his ranch, while the other part—a special brand—he bought from an importer.

After our farmer had spent all summer on his country place he decided when autumn came to enjoy the winter months elsewhere.

To be sure that his farm hand would continue the successful feeding of his cows and that the creatures might flourish and continue delivering the same quality of rich milk he prepared a carefully and specifically worded memoranda of instructions.

Feeling assured that all was well planned for the coming winter, he departed for the city to enjoy the products of his ranch, together with his contented customers there.

As time drifted along, there gradually was expressed to him one complaint after another by his customers over the quality of the milk that was delivered to them and finally the quantity also decreased to such an extent that a number of customers were left completely without the white beverage.

Dismayed and chagrined our farmer took an early train for his ranch.

On reprimanding his farm hand for the bad quality and decreased quantity of milk he had delivered, the farm hand took his employer to the written feeding in-

structions carefully nailed on the wall and from there to the barn and there showed that the imported feed had come to an end. The instructions on the wall did not specify any alternative in case one or the other of the feeds would run short.

The farm hand offered the written instructions and the lack of imported feed as excuses for the shortage of milk and for the inferior quality. He had never considered applying himself any remedy nor had he considered advising with his employer, since no such proviso was made on the written instructions.

The farm hand happened to be a stickler for the letter and received his just reward for being so unteutonic in his management. He was fired!

By naming the "ranch owner," "Congress;" the "customers," "the people;" the "cows," "electrochemical industries;" the "ranch," "Niagara Falls;" the "feed," "hydroelectric power;" and the "farm hand," "Baker," the story is pretty nearly true—all but for the "fired."

J. W. B.

San Francisco, Cal.

Legal Status of Flotation Processes

To the Editor of Metallurgical & Chemical Engineering

SIR:—The decision handed down by the United States Supreme Court in the case of Minerals Separation, Ltd., et al. versus James M. Hyde is of importance quite as much from the light it throws upon the unnecessary impediments to the normal growth of industry which arise from our present system of issuing and adjudicating patents as from any bearing it may have upon the development of ore-dressing practice.

The patent upon which the charge of infringement was based, and the validity of which was denied, by the defendant is U. S. Patent No. 835,120. It will readily be understood that after 800,000 improvements in apparatus or processes have been covered by patents in this country, further "improvements," as we ordinarily call inventions, as termed in patent law, are likely to be so restricted in scope as to require very close and exact definition.

The patent in suit has been claimed by its owners to be a broad basic patent covering practically all of the commercially profitable methods of concentrating ores by the flotation processes. The specification of the patent relates that "we have found that if the proportion of the oily substance be considerably reduced, say to a fraction of 1 per cent on the ore, granulation ceases to take place, and after vigorous agitation there is a tendency for a part of the oil-coated metalliferous matter to rise to the surface of the pulp in the form of a froth or scum." The claims all call for agitation as the means of forming a froth with the use of "a small quantity of oil," or with oil, or oleic acid in amounts less than 1 per cent of the weight of the ore treated. A study of the "file wrapper" correspondence between the Patent Office and the inventor's patent attorney shows that the inventors applied for a claim covering "the process of concentrating ores which consists in separating the mineral from gangue by coating the mineral with oil in water containing a fraction of 1 per cent of oil on the ore, and recovering the oil-coated mineral," and a claim wherein was described a process in which the pulp was to be subjected to the action of compressed air for a separation of part of its valuable constituents after being treated by the methods de-

scribed in the other claims. The Patent Office refused to grant the claim not specifying agitation as the means of producing the froth, and also refused to grant the compressed air claim as not coming within the patent, but constituting an alternative concentration method.

The most marked feature of the decision granted by the Supreme Court is that it differs with all other decisions which have been passed upon the validity or construction of this patent. The United States Patent Office is held to have erred in granting too broad a patent. By inference, the German Patent Office was wrong in refusing to grant this same patent, which it held to make no new disclosure or contribution to the art of ore dressing. The District Court of Montana is held to have been in error in holding valid those claims of the patent which are not restricted to the use of a fraction of 1 per cent of oil. The District Court of Delaware made the same error, and also in the Miami case held the patent to cover operations which do not include agitation as defined by the Supreme Court as used in this patent. The Circuit Court of Appeals for the Ninth Circuit is reversed in its decision that the patent is invalid as a whole.

The Supreme Court says in part in the decision delivered by Mr. Justice Clark: "While we thus find in favor of the validity of the patent, we cannot agree with the District Court in regarding it valid as to all of the claims in suit. As we have pointed out in this opinion, there were many investigators at work in this field to which the process in suit relates when the patentees came into it, and it was while engaged in study of prior processes that their discovery was made. While the evidence in the case makes it clear that they discovered the last step which converted experiment into solution, 'turned failure into success' (the Barbed Wire Patent, 143 U. S., 274), yet the investigations preceding were so informing that this final step was not a long one, and the patent must be confined to the results obtained by the use of oil within the proportions often described in the testimony and in the claims of the patent as 'critical proportions' amounting to a fraction of 1 per cent on the ore."

The Supreme Court clarifies the issues of the case by clearly defining the scope of the process in these words: "The process of the patent in suit, as described and practiced, consists of the use of an amount of oil which is 'critical,' and minute as compared with the amount used in prior processes, 'amounting to a fraction of 1 per cent on the ore,' and in so impregnating with air the mass of ore and water used, by agitation—'by beating the air into the mass'—as to cause to rise to the surface of the mass, or pulp, the froth, peculiarly coherent and persistent in character, which is composed of air bubbles with only a trace of oil in them, which carry in mechanical suspension a very high percentage of the metal and metalliferous particles of ore which were contained in the mass of crushed ore subject to treatment."

Agitation, as the term is used in the patent, is thus defined in the complainants' own language as being such rapid mechanical stirring "by beating the air into the mass" as to impregnate the mass of ore and water with air sufficient to cause a very high percentage of the valuable minerals to float as a froth. That is undoubtedly the sense in which the patentees used the term "agitate to produce a froth" in this and allied patents in which no other means is mentioned by which the air necessary to produce a froth is to be introduced into the pulp. This patent specifically disclaims the generation of a gas within the pulp by the use of sulphuric acid as coming within the scope of the patent, and as has been previously pointed out the Patent Office

refused to grant the claims calling for no means of introducing the froth-producing gas, or making compressed air the means of producing a froth.

The pneumatic process of flotation concentration which has come into such extensive use, and is preferred to the agitation froth process by many operators, was broadly described in a patent taken out in Great Britain by Minerals Separation and Theodore J. Hoover in 1910. This patent broadly describes a process for concentrating ores by introducing a gas of any kind through a permeable medium into an oiled ore pulp for the purpose of causing the oiled mineral to float as a froth and overflow and thereby be separated from the gangue minerals. Several methods were described for accomplishing this result and a number of forms of apparatus were described. It is understood that when an inventor in this country who had independently discovered this same process applied to the United States Patent Office for a patent covering this method, he was denied a patent on the ground that the process had been disclosed in the British patent and was already open to free use in this country, as its original inventors had taken out no patent covering the process in the United States.

The claim has been made that the process just passed upon is a broad basic patent covering the production of a mineral-bearing froth as a means of separating the metalliferous contents of an ore from the gangue, and throughout the suit the witnesses for the complainant constantly described the result of this process as a froth while no other process was held to make a froth. It is interesting to note that in 1910, five years after the alleged discovery of the process of the patent in suit, Minerals Separation took out two patents for processes in which it was said that there were already a number of well-known processes for producing concentration by the means of froth, stating: "The processes employed to obtain these froths or scums may be any of the well-known flotation processes as described, for example, in"—then is given a list including the patent under discussion and two patents preceding it, one of which is the Froment process, which was relied upon by the defense as one of the most important anticipations of the patent in suit. The Froment process patent was taken out about three years before the alleged invention of the process of the patent just passed upon by the Supreme Court. It was testified by one of the alleged inventors of the agitation froth process that he had in his safe for over two years preceding the alleged invention of the agitation froth process a report by Alcide Froment describing how his process should be worked, and that this report had never been seen by anyone save himself and the other two alleged inventors of the agitation froth process. The Froment pneumatic process was patented in Great Britain but not in the United States.

The decision of the Supreme Court seems to have been granted upon the assumption that there is a "critical proportion of oil," and that this critical amount is "a fraction of 1 per cent of the weight of the ore treated. The term 'critical proportion of oil' is evidently used to convey the impression that there is a proportion of oil which will result in the production of a froth while more than that amount will not. The further impression was created that this critical proportion is "a fraction of 1 per cent of the weight of the ore treated." If these assumptions are correct it is to be assumed that the earlier processes referred to in the 1910 patents as "well-known flotation processes which produce a froth" must have used this critical proportion.

The defense introduced into evidence a number of tests using more than 1 per cent of oil which made as thick and permanent a froth as is obtained with less than 1 per cent of oil and yielded as good concentrates

and as high recovery. These tests were all made in an apparatus which it was conceded by all concerned was the best to be used in determining what could be done on a commercial scale, but these tests were objected to by the complainants as being mere laboratory tests. Several of these tests were repeated in the court room. Judge Gilbert in rendering the opinion of the Circuit Court of Appeals referred to this phase of the case as follows:

The contention is made, however, that if indeed the prior patents disclose froth processes, the scum which the appellees' process causes to rise to the surface of the water is so different from the froth or scum which arises under the prior art, that it is a new result, and is not anticipated by anything in the prior art. Say counsel for the appellees: "You produce a froth which is not our froth," and again they say that the appellees' froth is "a pure metal froth," while that of the other patents is an "oil froth," and that the appellees' froth consists of air bubbles surrounded by metal armor without any appreciable quantity of oil compared therewith. The evidence in the case, together with the illustration thereof afforded by demonstration of the various processes which were made in the aid of the argument before this court, convince us that the froth in all these processes is the same, with the exception that there is less oil (as there must necessarily be) in the appellees' froth than in the others. The froths are all similar in appearance, they all rise to the surface after the same amount of agitation, they all gather with equal efficiency the same quantity of metal, and they are all removed from the surface in the same way. It is not literally true, of course, that there is no oil in the froth which the appellees produce. If there were no oil in it, there would be no froth. The quantity of oil that has been put into the mixture must necessarily be found in the froth. It would manifestly be a physical impossibility to create a froth consisting only of bubbles of air and the particles of mineral.

The decision of the Appellate Court was:

We hold that to sustain the appellees' patent would be to give to the owners thereof a monopoly of that which others had discovered. What they claim to be the new and useful feature of their invention, as stated by their counsel, is "agitating the mixture to cause the oil's coated mineral to form a froth." As we have seen, that feature was clearly anticipated by the prior art, and when the elements of the appellees' claims are read one by one, it will be found that each step in their process is fully described more than one of the patents of the prior art, with the single exception of the reduced quantity of oil which they use. The patentees of the appellees' patent made a valuable contribution to the art in discovering the smallest quantity of oil which would produce the desired result. In doing so, they opened the course to which all skillful metallurgists would be expected to pursue. They made a series of experiments to determine how small a quantity of oil could be used successfully. They found, as all must find who apply the oil flotation process, that certain oils are adapted to use with certain ores, and that a larger quantity of oil is necessary for one kind of an ore than for another. The appellees admit that for some ores they use four times as much oil as for others. Their discovery that a small fraction of 1 per cent of oil is sufficient to produce flotation of the metalliferous matter cannot, as we have seen, be made by itself or in combination the subject of a patent. The appellees cannot take from others the right to use oil economically.

We are reliably informed that so soon as they learned of the decision of the Supreme Court, the staff of one of the largest mills which is using the agitation froth process raised the amount of oil used to more than 1 per cent and that they still get the froth result with as good concentrates and slightly better recovery. It is found necessary to use less of other reagents, and the grade of oil now used is so cheap that the net profits are practically what they were before. Other companies are adopting the same practice.

Apparently the decision of the Supreme Court was based upon a false assumption as to the facts involved, and the net result of litigation extending over five years' time and costing a fortune is, that after having proceeded within their free rights for two years and a half the companies using the agitation froth process are to be compelled to do what the court previously told them they could not be compelled to do; that is, to use more oil than is necessary to accomplish the result desired.

If, as is demonstrated by this case, the courts cannot be expected to agree with each other with regard to the interpretation of the law and the bearing of facts, it should be apparent that the least possible interference with the progress of industry would come from having all patent cases heard by a single court constituted of judges selected for their technical training and experience and knowledge of the law, this court being a part of the Patent Office and having sole and final jurisdiction in all patent litigation. A certain degree of con-

sistency and uniformity of patent decisions might be expected from such a court.

In the meantime it is probable that in the course of the further litigation arising over this process, the Supreme Court may be convinced that its decision was based upon a false assumption as to the existence of a "critical proportion, a fraction of 1 per cent of oil," and sustain the Court of Appeals' verdict, which was based upon a conception of facts substantiated by the operations of large mills."

A. B. C.

Chemical Credits*

By Ellwood Hendrick

The late J. P. Morgan said that if a man had character he would not hesitate to lend him a million dollars without security, but that if he knew him to be deficient in this respect no amount of security would enable the man to borrow money from him. That was a pretty broad statement, but it indicates the nature of credit. Credit is wealth, if you please, but it is of a kind that cannot be obtained ready made. It is, in a sense, an article of barter, because nothing is so easy for a man to trade away as his credit. And yet, it is not merchandise, because the man to whom the original owner trades his credit gets nothing in return but experience. Some kinds of experience may be transformed into credit, but not all. Credit-experience is not exactly a reversible reaction.

Chemical credits are needed, but they are not thoroughly established. Their position is something like that of a St. Louis man, going into a Boston bank to borrow money on Australian securities. Everything is all right except that the transaction does not go through.

The banker does not know the security and he does not know the man. And when we consider how little chemists are known among bankers the problem of the man without a pull is really bewildering when it comes to launching an enterprise.

The business practices of what for want of a better name is called private banking, or sometimes investment banking, have curious psychological sequelæ. Information being the life of the business, it is likely to be secret, and this makes the private banker secretive. On the other hand, among themselves private bankers are gregarious, and they hate to go it alone. It is their habit to invest in series or *en cascade*, so that when two or three leaders subscribe to the underwriting of an enterprise others are likely to follow without much examination. Subscription books close, and there is always the danger that one may be too late. Indeed, there sometimes appears to be as much worry and agony of spirit borne by a banker who invests some money on his own judgment successfully as when he loses the same sum along with the leading houses in the financial district. He dreads solitude in trouble.

The problem, then, in financing an enterprise, is to establish to the satisfaction of one and preferably more than one banker, the merit of the undertaking and the character and ability of the men in charge. Now it is not given to us in youth, as a rule, to select the class at college or the fraternity to which belongs the prospective banker whom we shall want to approach twenty years or more later. It is not given to all of us to live in the same neighborhood as those with funds to invest at the time that we are in the market, and there are a thousand reasons why we may not adjoin or share in opera boxes. The social side of business, however, while still of great weight, is not the sole basis of credit.

The first step in the line of credit is the commercial

*An after-dinner address delivered at the banquet of the American Institute of Chemical Engineers on Jan. 11, 1917.

report, and even here the chemical enterprise is in a bad way. There may be commercial agencies that know how to get the details about an undeveloped or unusual chemical industry and correlate them and get the professional and business records of the men engaged in it, but I have yet to see one. The fact is to make a good, exhaustive report on such an enterprise takes not only time, but chemical knowledge and understanding, and this is just what seems to be lacking. There is, however, no reason why this should not be done. The machinery for gathering full information as to the character and ability of men is at hand in the commercial agencies, and so is that for gleaned information as to the market for special products all over the country. The only thing lacking is chemical direction. Under this there would be gathered and correlated, in addition to the usual information, the very things that it takes a chemical engineer to find out. To the uninformed man location, raw materials, processes and products mean little more than nothing. The chemist can put meaning into them.

How can this be brought about? How can there be established a means for an investor or investors' agent to secure a reliable report on new and changing chemical establishments? How can he get one that he can understand from a source that he knows and on the word of which he is accustomed to determine his credits?

I venture the belief that two or three afternoon sessions of two or three of the right chemical engineers with a couple of sound bankers who have experience in the development rather than the promotion of new enterprises, together with the proper authorities of a mercantile agency that wanted to do this thing, could establish a type of report and lay the foundation of chemical credits. The needful things are: desire by the mercantile agency to do this thing and a willingness on its part to pay for chemical information. I think the chemical engineers and the bankers would gladly contribute time and thought to bring this about.

Coming Meetings and Events

American Paper and Pulp Association, Technical Association, New York, Feb. 6, 7 and 8, 1917.

Joint meeting of New York Section of American Electrochemical Society, American Chemical Society and Society of Chemical Industry, Rumford Hall, Chemists' Club, New York, Feb. 9, 1917.

American Institute of Mining Engineers, annual meeting, New York, Feb. 19-22, 1917.

Program of New York Meeting of American Institute of Mining Engineers

The one hundred and fourteenth meeting of the American Institute of Mining Engineers will be held in New York City, Monday, Feb. 19, to Thursday, Feb. 22, inclusive. A most attractive program has been prepared including the usual technical sessions and entertainment features.

Monday evening will be "College Reunion Night" in the assembly rooms of the Engineering Societies' Building, at 8:30 p. m. Light refreshments and "smokes" will be served. Impromptu addresses will be made with occasional moving pictures of a non-technical character, and other features will be provided to liven things up.

The annual dinner will be held at the Astor on Tuesday evening.

On Wednesday evening a lecture will be given on colored moving pictures and on Thursday an all day

excursion will be made to West Point on a special train. The condensed program and part of the technical program follow:

Special entertainment features will be provided for the ladies as usual.

SUMMARIZED PROGRAM

MONDAY, FEB. 19, 1917

- 9.00 a.m. to 5.00 p.m.—Registration at Institute Headquarters.
- 10.00 a.m.—Simultaneous Sessions on Geology and on Metallurgy.
- 12.30 p.m.—Luncheon at Engineering Societies' Building.
- 2.00 p.m.—Simultaneous Sessions on Petroleum and Gas and on Milling and Smelting.
- 8.00 p.m.—College Reunion Night.

TUESDAY, FEB. 20, 1917

- 10.30 a.m.—Annual Business Meeting followed by Technical Session.
- 12.30 p.m.—Luncheon at Engineering Societies' Building.
- 2.00 p.m.—Simultaneous Sessions on Iron Blast Furnace Practice and on Flotation.
- 6.30 p.m.—Annual Dinner at Hotel Astor, followed by Dancing.

WEDNESDAY, FEB. 21, 1917

- 10.00 a.m.—Session on the Manufacture of Iron and Steel.
- 12.30 p.m.—Luncheon at Engineering Societies' Building.
- 2.00 p.m.—Simultaneous Sessions on Metallography and Heat Treatment of Steel and on Mining Methods.
- 8.00 p.m.—Entertainment and Lecture at Engineering Societies' Building.

THURSDAY, FEB. 22, 1917

- All-day excursion by special train to West Point. (Exhibition horseback riding, inspection of buildings, etc.)

TECHNICAL SESSIONS

MONDAY, FEB. 19, 1917

- 10.00 a.m.—Session on Metallography.
- Grain Growth Phenomena in Metals. By Zay Jeffries.
- On Grain Growth. By Henry M. Howe.
- Recrystallization after Plastic Deformation. By Henry M. Howe.
- Tungsten and Molybdenum Equilibrium Diagram, and System of Crystallization. By Zay Jeffries.
- The System Tungsten-Molybdenum. By Frank Alfred Fahrwald.
- 2.00 p.m.—Session on Milling and Smelting.
- Magnetic Concentration of Low-Grade Magnetic Iron Ore. By S. Norton and S. Le Fevre.
- An Investigation on Rock Crushing Made at McGill University. By John W. Bell.
- Countercurrent Decantation. By Luther B. Eames.
- The Function of Alumina in Slags. By Carl Heinrich.
- A Method for Measuring the Viscosity of Blast-Furnace Slag at High Temperatures. By Alexander L. Field.
- Matte Granulation at Herculaneum, Mo. By S. Paul Lindau and Henry B. Smith.

TUESDAY, FEB. 20, 1917

- 10.00 a.m.—Session on Non-Metallic Minerals. (Following Annual Business Meeting.)
- A Study of the Silica Refractories. By J. Spotts McDowell.
- The Genesis of Asbestos and Asbestiform Minerals. By Stephen Taber.
- The Conservation of Phosphate Rock in the United States. By W. C. Phalen.
- 2.00 p.m.—Session on Iron Blast-Furnace Practice
- Dry-Hot versus Cold-Wet Blast-Furnace Gas. By Linn Bradley, H. D. Egbert and W. W. Strong.
- Some Suggestions Regarding Construction of Hot Blast Stoves. By Linn Bradley, H. D. Egbert and W. W. Strong.
- Calculations with Reference to the Use of Carbon in Modern American Blast Furnaces. By Henry Phelps Howland.
- Potash as a By-Product from the Blast Furnace. By R. J. Wysor.
- 2.00 p. m.—Session on Flotation
- Notes on Flotation—1916. By J. M. Callow.

WEDNESDAY, FEB. 21, 1917

- 10.00 a.m.—Session on the Manufacture of Iron and Steel.
- The Seasoning of Castings. By Richard Moldenke.
- Significance of Manganese in American Steel Metallurgy. By F. H. Willcox.
- Roll Scale as a Factor in the Bessemer Process. By A. Patton and F. N. Speller.

Temperature Measurements in Bessemer and Open-hearth Practice. By George K. Burgess.

The Manufacture of Weldless Steel Tires for Locomotives and Car Wheels. By Guillaume Aertsen.

2.00 p. m.—Session on Metallography and Heat-Treatment of Steel

Notes on the Heat Treatment of High-Speed Steel Tools. By A. E. Bellis and T. W. Hardy.

Effect of Time in Reheating Hardened Steel Below the Critical Range. By C. R. Hayward and S. S. Raymond.

Erosion of Guns—The Hardening of the Surface. By Henry Fay.

The Effect of Sulphur on Low-Carbon Steel. By Carle R. Hayward.

A Method for Distinguishing Sulphides from Oxides in the Metallography of Steel. By George F. Comstock.

Symposium on the Smelter Smoke and Fume Problem

Three interesting papers on the smoke and fume problem were presented on Friday evening, Jan. 26, at a joint meeting of the New York Sections of the American Electrochemical Society and American Institute of Mining Engineers, held at the Machinery Club.

Mr. LIGON JOHNSON, consulting attorney for the International Nickel Company, and the American Smelting & Refining Company, was the first speaker. He outlined in a very interesting manner the whole legal history of the smoke and fume problem, and then explained the large amount of experimental work done by the American Smelting & Refining at Salt Lake City and other points, in determining the actual extent of the harm done by waste smelter gases to plant life. It was found that all the harm done to plant life was due to SO_2 , or mixtures of SO_2 and SO_3 , when the plants are in leaf. The visible fume was found to have little effect, it being the invisible fume which does the damage. High stacks and hot exit gases are recommended for visual clearance.

Mr. W. W. STRONG gave a very interesting talk on "Theoretical Aspects of Electrical Precipitation," explaining the corona discharge, electrical wind, and showing just how the precipitation is accomplished. His talk was illustrated with some interesting slides.

Mr. LINN BRADLEY discussed the latest developments in the use of the Cottrell process. One of the most interesting points brought out by him was the necessity of having conditions in all the tubes the same, i.e., regarding each tube in a several tube unit, as a single tube and keeping the conditions in each tube the same as found successful in preliminary experiments, which are made in a single tube. Mr. Bradley concluded his part of the program with some interesting moving pictures of recent Cottrell installations, in connection with brass melting, slate grinding, and smelting.

Both the dinner and the technical session were well attended, there being about 200 present.

Current News and Notes

Local Refining of Metals Planned in Canada.—It is expected that a government bill will be introduced at the approaching session of Parliament in Ottawa, which will provide aid by bounty or tariff for the increased refining of lead, copper and zinc in Canada.

Rubber Club Holds Annual Meeting.—The annual meeting and banquet of the Rubber Club of America was held at the Waldorf-Astoria, New York City, on Monday, January 8. Divisional meetings and business meetings were held during the day and the banquet at 6:30 p. m. The principal speakers at the

banquet were Ex-President William H. Taft, Colonel Samuel P. Colt, president of the United States Rubber Company, and Samuel McRoberts, vice-president of the National City Bank, the latter substituting for Frank A. Vanderlip, president of the National City Bank. It had been planned to have a symposium on crude rubber to take up the question of insuring a supply of crude rubber to the country at all times, but there were so many other functions that this had to be postponed to a later date.

Foreign Trade Convention.—The Fourth National Foreign Trade Convention of the National Foreign Trade Council will be held at the William Penn Hotel, Pittsburgh, Pa., January 25, 26 and 27, 1917. Many important questions will be discussed such as the following: Conditions in foreign markets after the war, and the measures necessary to safeguard American foreign trade, as well as the foreign trade aspect of the American tariff system; co-operation in foreign trade development; the American merchant marine; foreign investment of American capital as an aid to oversea commerce, and problems of the smaller manufacturer and merchant.

Course for Prospectors at University of Utah.—The School of Mines and Engineering of the University of Utah, Salt Lake City, has established a course for prospectors, which will be given this winter during the four weeks from Jan. 8 to Feb. 3. The course will cover the fundamentals of geology, mineralogy, mining and the metallurgical treatment of ores. Professor Robert S. Lewis is in charge of the mining department.

Meeting of Mining and Metallurgical Society.—The annual meeting of the Mining and Metallurgical Society of America was held at the Engineers' Club, Jan. 9. The officers elected for the coming year are W. R. Ingalls, president; Waldemar Lindgren, vice-president; Louis D. Huntoon, secretary-treasurer. The annual gold medal of the Society was awarded to E. P. Mathewson for his achievements in non-ferrous metallurgy. Action was taken endorsing Belgian Kiddies, Ltd., and David H. Browne spoke on Mr. Hoover's work and urged greater support for this movement. Mr. George S. Rice of the Bureau of Mines spoke on the Joseph A. Holmes Safety Association and Mr. H. W. DuBois showed some interesting mining pictures of Alaska.

The Colorado Section of the A. I. M. E. held its annual meeting on January 15, 1917, at the University Club in Denver. The following officers were elected for the coming year: Chairman, Chas. Loughridge; vice-chairman, George M. Taylor; directors, Fred A. Bostwick and P. M. McHugh; secretary and treasurer, Fred Carroll. The meeting was non-scientific; the program involved the following numbers of note: Address by L. D. Ricketts, president of the A. I. M. E., over long-distance telephone; "Flotation Exposed and Explained," by H. C. Parmelee, and "The Latest Practice in Cyanide Milling," by T. B. Stearns. Each member present at the banquet had a telephone at his place so as to be sure to hear Dr. Ricketts' voice. Dr. Ricketts' proxy was Mr. Stearns, located in an adjoining room. Most of the crowd were fooled. Mr. Parmelee showed, by very elaborate tests, the value of the flotation process. The experiments consisted in proving once and for all that cork will sink and galena will float. To demonstrate the latest practice in cyaniding, Mr. Stearns made use of the celebrated Metallurgical Cow. The meeting was a success from start to finish and all the members left on their homeward trip thoroughly convinced that both flotation and the new cyanide practice were here to stay.

The Calculation of Lead Blast Furnace Charges—II.

By Boyd Dudley, Jr.

(Concluded from page 93)

PROBLEM II.

Materials of compositions shown in the following table are to be smelted in the lead blast furnace.

Material	H ₂ O, Per Cent	Pb, Per Cent	Cu, Per Cent	SiO ₂ , Per Cent	Fe, Per Cent	Mn, CaO, Per Cent	MgO, S, Per Cent
D. and L. sinter	0.0	37.20	1.35	17.3	18.4	2.1	10.3
Silicious mixture	4.7	5.35	0.65	50.4	10.2	1.1	5.8
Pyrite cinder	2.3	0.0	0.38	10.6	58.2	0.0	2.3
Lime stone	4.2	0.0	0.0	6.5	5.3	0.0	43.2
Coke	0.0	0.0	0.0	5.2	1.2	0.0	1.1

Conditions and assumptions: The supplies of D. and L. (Dwight and Lloyd) sinter and of the silicious ore mixture are such that these two materials must be charged in equal quantities to the furnace. With them enough pyrite cinder, limestone, and coke are to be smelted to conform to the following assumed conditions.

It is desired to produce a slag that will contain silica 32 per cent, ferrous oxide 38 per cent, and lime 20 per cent, leaving 10 per cent to be formed by the minor constituents.

The amount of coke is to be 14 per cent of the charge.

Assume that 20 per cent of the sulphur charged to the furnace will escape with the gases, that the slag produced will analyze 1.0 per cent of sulphur, and that the remaining sulphur will form matte containing 23.0 per cent of sulphur and 46.0 per cent of iron. Assume also that all of the copper of the charge will enter the matte, and that sulphur, iron, copper, and lead will constitute 90.0 per cent of the matte as it is produced.

Assume that 4.0 per cent of the lead on the charge will be volatilized and escape with the furnace gases, that the slag will analyze 0.70 per cent of lead, and that the bullion produced will contain 97.0 per cent of lead.

Required: a—Determining the amount of pyrite cinder, of limestone, and of coke to be charged with 1000 lb. of D. and L. sinter and 1000 lb. of the silicious mixture, dry weights being considered.

b—Calculate the wet weight of each material to be employed in making an 8000 lb. charge, exclusive of the coke. What amount of coke should accompany such a charge?

c—What will be the matte fall, *i. e.*, what per cent will the matte be of the charge that produces it? Calculate the approximate composition of the matte.

d—What will be the bullion fall, *i. e.*, what per cent of the charge is the bullion that it produces? Compare this with the per cent of lead on the charge.

Notes: In order to secure uniformity it is customary to make chemical analyses on samples that have been dried at a constant temperature, say 105° C. The loss in weight at this temperature is generally reported as moisture, and the amounts of the determined constituents are calculated as percentages of the dry weight. The moisture, on the other hand, is calculated as a per cent of the wet weight. The reason for this procedure should be evident. When the materials that enter into a furnace charge are weighed, the moisture that each contains has to be taken into account, and this can best be done by deducting the determined percentage of moisture in terms of the wet weight. There is thus left the net or dry weight, to which the various percentages of the chemical analysis apply.

The coke analysis given in the table is based upon the air dried weight, which is the one generally employed unless the coke is shipped or stored under conditions that may expose it to excessive wetting.

It will be observed that among the chemical constituents specified in the table there are manganese and magnesia in addition to those considered in the previous problem. The occurrence of these is a quite common thing, and they are generally taken into account in the following manner:

The atomic weight of manganese is 54.93, while that of iron is 55.84. Furthermore, the chemical characteristics of the two elements have much in common. Therefore, when manganese is present in not too great amounts, it may be considered as having the same chemical effect as iron, and the amount of one may be added directly to the amount of the other. It is also customary to consider the atomic weight of iron or of combined iron and manganese as 56 rather than to employ the more exact figure 55.84. This is a justifiable approximation and produces a simple ratio between iron and ferrous oxide,

$$\text{Fe} : \text{FeO} = 56 : 72 = 7 : 9.$$

This relationship was employed in the previous problem and will be employed in this and the succeeding one.

In a similar manner magnesia may be considered as having much the same effect as lime. But owing to the difference between the molecular weights of these compounds, the magnesia is the more effective of the two as a basic slag constituent, and if, for the sake of simplicity, it is desired to add magnesia to lime and to consider both oxides as lime, the magnesia must be given its proper lime value. This is done on the assumption that a molecule of magnesia has the same chemical effect in the slag as does a molecule of lime. Hence, the molecular weight of magnesia being 40 and that of lime being 56, one unit of magnesia is equivalent to $56 \div 40 = 1.4$ units of lime.

While the calculation of magnesia as lime according to the above ratio is a justifiable short cut, it introduces an alteration of the original set of assumed conditions that should be pointed out. It was assumed that silica, ferrous oxide, and lime would together constitute 90 per cent of the slag produced, the remainder being composed of alumina, zinc, sulphur, lead, etc. But now it is proposed to consider each unit weight of magnesia present as 1.4 units of lime, and still to calculate the silica, ferrous oxide, and lime thus determined as aggregating 90 per cent of the slag. It is evident that percentages and molecular weights are here being combined in a manner that is theoretically incorrect. But unless the amounts of magnesia in the charged materials are high, the error thus introduced is of little practical importance, and the calculations are greatly simplified by this procedure.

Solution: As before, it is well to calculate the slag ratios at the outset, taking a unit weight of silica as the standard. For each pound of silica in the slag there will be other constituents as follows:

$$\text{Iron} = \frac{38\% \text{ FeO}}{32\% \text{ SiO}_2} \times \frac{7}{9} \text{ (ratio Fe to FeO)} = 0.924 \text{ lb.}$$

$$\text{Lime} = \frac{20\% \text{ CaO}}{32\% \text{ SiO}_2} = 0.625 \text{ lb.}$$

$$\text{Sulphur} = \frac{1\% \text{ S}}{32\% \text{ SiO}_2} = 1/32 \text{ lb.}$$

That is, the amounts of silica, iron, lime, and sulphur in the slag should be present in accordance with the relation:

$$\text{Silica} : \text{Iron} : \text{Lime} : \text{Sulphur} = 1.00 : 0.924 : 0.625 : 1/32.$$

Before proceeding to draw up a charge sheet the analyses of the different materials can be simplified according to the notes outlined above. Thus in the D. and L. sinter:

18.4% Fe + 2.1% Mn = 20.5% Fe, and
 10.3% CaO + (1.2% MgO $\times$ 1.4) = 12.0% CaO.
 In the silicious ore mixture:
 10.2% Fe + 1.1% Mn = 11.3% Fe.
 In the limestone:
 43.2% CaO + (3.2% MgO $\times$ 1.4) = 47.7% CaO.

The various materials with their simplified analyses may now be entered on a charge sheet, which may conveniently have the following form. In this case the lead and copper figures may be omitted for the present, and since the D. and L. sinter and the silicious mixture are to be smelted in equal quantities, 1000 lb. of each may be entered at once on the sheet. This has been done in lines *a* and *b*, and the amounts of the constituents thus provided have been calculated and entered in their proper places.

Material	Dry Wt.	Silica		Iron		Lime		Sulphur	
		Per Cent	Wt.	Per Cent	Wt.	Per Cent	Wt.	Per Cent	Wt.
<i>a</i> —D. & L. sint.	1,000	17.3	173	20.5	205	12.0	120	4.37	43.7
<i>b</i> —Silic. mixtr.	1,000	50.4	504	11.3	113	5.8	58	5.28	52.8
<i>c</i> —Tt's <i>a</i> & <i>b</i>	2,000			677	318		178		96.5
<i>d</i> —Pyrite cind.	950	10.6	101	58.2	553	2.3	22	1.87	17.8
<i>e</i> —Limestone.	680	6.5	44	5.3	36	47.7	324	0.43	2.9
<i>f</i> —Coke	508	5.2	26	1.2	6	1.1	6	1.24	6.2
<i>g</i> —First trial totals			848		913		530		123.4
<i>a</i> —Tt's <i>a</i> & <i>b</i>	2,000			677	318		178		96.5
<i>d</i> —Pyrite cind.	950		104		573		23		18.4
<i>e</i> —Limestone.	685		45		36		327		2.9
<i>f</i> —Coke	615		27		6		6		6.2
<i>h</i> —Second trial totals			853		933		534		124.0

The amounts of silica, iron, lime, and sulphur in the D. and L. sinter and in the silicious mixture may now be added. The respective totals have been entered in line *c* of the charge sheet. The problem has now resolved itself into a very simple form. It is only necessary to provide pyrite cinder, limestone, and coke in proper quantities for the amounts of various constituents shown in line *c* of the sheet. The method of making estimates of these quantities and of finally balancing the charge is as follows:

To estimate the amount of pyrite cinder, consider the totals of line *c*. Of the 96.5 lb. of sulphur present 80 per cent will remain in the furnace and enter the matte and slag. The exact amount of this that will ultimately enter the slag is a matter of speculation. But it is seen that the silica of line *c* amounts to 677 lb., and according to the assumed slag ratio each unit of silica will be accompanied in the slag by 1/32 unit of sulphur. Therefore, considering the material of line *c* alone it is seen that:

Sulphur to matte and slag = 96.5 lb. $\times$ 0.80 =	77.2 lb.
Sulphur to slag = 677 lb. $\div$ 32 =	21.2 lb.
Sulphur to matte after deducting gas and slag losses =	56.0 lb.
Iron present for slag and matte =	318 lb.
Iron required for matte = 56 lb. $\times$ 2 =	112 lb.
Iron available for slag =	206 lb.
Silica present for slag =	677 lb.
Silica provided with iron = 206 lb. $\div$ 0.924 =	223 lb.
Silica of line <i>c</i> in excess of iron =	454 lb.

It is evident that there is 454 lb. of silica in line *c* that will require iron from an external source. Now consider the analysis of the pyrite cinder. The 10.6 per cent of silica present therein will require approximately 10 per cent of iron in forming slag. There is also present 1.87 per cent of sulphur, a part of which will require iron in forming matte. A quick mental estimate shows that the amount of iron so required will not be less than 2 per cent. Hence approximately 12 per cent of the iron of the pyrite cinder will be required by the silica and sulphur of that material. There re-

mains practically 46 per cent of available iron, which may be employed in supplying the deficit of iron in line *c*.

The pyrite cinder required to furnish free iron for 454 lb of silica is

$$454 \text{ lb.} \times 0.924 = 913 \text{ lb.} \\ 0.46$$

This amount of pyrite cinder would provide the necessary iron for the materials of lines *c* and *d*, but these materials are not to be smelted alone. There must still be added certain amounts of limestone and coke, both of which contain silica and also sulphur. Inspection of the limestone analysis shows that iron and silica are fairly well balanced in this material, although there is a small amount of sulphur, which the iron may not fully cover. On the other hand, the coke is seen to contain a large excess of silica over iron and also to contain considerable sulphur. It is therefore clear that the 913 lb. of cinder estimated above will prove insufficient to provide iron for the entire charge. The amount to be added to 913 lb. of pyrite cinder in order to allow iron for the silica and sulphur of the coke might be estimated by a process similar to that which has been followed up to the present. But in general such an estimate will consume more time than will an arbitrary addition to the estimated amount and a trial of the charge to determine whether or not it is properly balanced. For instance, suppose that in this case 950 lb. of pyrite cinder is entered in line *d*. Understand, this is a purely arbitrary increase over the amount first estimated. It may be too much or too little. Judgment and previous experience may be well used in this case, although they are not in any way essential. Calculate and enter the constituents of 950 lb. of pyrite cinder in their respective spaces in line *d*.

Now proceed to estimate the amount of limestone as follows. In lines *c* and *d* there are present 778 lb. of silica and 200 lb. of lime

Lime requirement of silica = 778 lb. $\times$ 0.625 =	486 lb.
Lime already present =	200 lb.
Lime required to supply deficit in lines <i>c</i> and <i>d</i> =	286 lb.

Considering the analysis of the limestone, 6.5 per cent of silica will require $6.5 \times 0.625 = 4.1$ per cent of lime. This leaves $47.7 - 4.1 = 43.6$ per cent of lime in excess of that required by the silica of the limestone itself, *i.e.*, 43.6 per cent of available lime. The amount of limestone required to provide 286 lb of available lime is therefore

$$\frac{286 \text{ lb.}}{0.436} = 656 \text{ lb.}$$

This will provide sufficient lime for everything on the charge except the coke, and the analysis of this material shows that there is a large excess of silica in it above the lime that it contains. Here again an estimate of the amount of limestone to add for the purpose of providing lime for the coke could be attempted, but suppose 680 lb. of limestone is entered for a first trial. This is an arbitrary increase to be sure, but it will not be far wrong and will probably be productive of a saving of time. Calculate and enter in line *e* the amounts of constituents in 680 lb. of limestone.

The coke may now be calculated and entered. The charge as it now stands consists of 1000 lb. of D. and L. sinter; 1000 lb. of silicious mixture; 950 lb. of pyrite cinder, and 680 lb. of limestone, making a total of 3630 lb. The amount of coke to be employed is 14 per cent of the charge. Hence

$$\text{Coke} = 3630 \text{ lb.} \times 0.14 = 508 \text{ lb.}$$

Enter this with its constituents in their proper places in line *f*.

The entire charge as thus estimated may now be

tested to determine whether or not the materials are present in proper proportions. The method of performing this operation is as follows.

Add the amounts of silica, iron, lime, and sulphur present on the charge, and enter the totals in line *g* of the sheet. Considering the figures therein,

Sulphur to matte and slag = $123.4 \text{ lb.} \times 0.80 =$	98.8 lb.
Sulphur to slag = $848 \text{ lb.} \div 32 =$	26.5 lb.
Sulphur to matte =	72.3 lb.
Iron on charge =	913 lb.
Iron to matte = $72.3 \text{ lb.} \times 2 =$	145 lb.
Iron to slag =	768 lb.
Iron required by silica = $848 \text{ lb.} \times 0.924 =$	783 lb.
Deficit of iron =	15 lb.
Lime on charge =	530 lb.
Lime required by silica = $848 \text{ lb.} \times 0.625 =$	530 lb.

It is thus seen that the charge as first estimated is properly balanced with respect to lime but lacks iron to the extent of 15 lb. This will necessitate an addition to the pyrite cinder, the amount of which will be approximately

15 lb. deficit of iron

0.46 available iron in cinder = 33 lb.

For convenience this may be increased to 35 lb., making the second estimate of pyrite cinder $950 \text{ lb.} + 35 \text{ lb.} = 985 \text{ lb.}$

In order to preserve a clean and neat sheet and at the same time to have the result of each trial in evidence it is better not to erase the first estimates, but to extend the charge sheet downward as has been done. In line *h* the totals of lines *a* and *b* have again been entered. In line *i* the new amount of pyrite cinder is entered, and the amounts of its constituents are computed and entered in their proper places.

Now for the limestone, in the first charge the lime was seen to be balanced to the nearest pound, but the addition of 35 lb. to the pyrite cinder will add silica to the charge in excess of the lime added, and this balance of lime will be disturbed. Hence, for a second trial the limestone should be increased as well as the pyrite cinder. Inspection of the cinder analysis with reference to silica and lime shows that an increase of 35 lb. in this material will introduce about 2 lb. of silica in excess of lime, and this may be corrected by adding 5 lb. to the limestone. Therefore, for a second trial the limestone should be increased from 680 lb. to 685 lb.

These additions to the charge will necessitate a corresponding increase in the coke, the new weight being $(2000 + 985 + 685) \text{ lb.} \times 0.14$

$$= 3770 \text{ lb.} \times 0.14 = 515 \text{ lb.}$$

Entering the 685 lb. of limestone in line *j* and 515 lb. of coke in line *k* yields the second completed charge, which can be tested as before.

Considering the totals entered in line *l*,

Sulphur to matte and slag = $124 \text{ lb.} \times 0.80 =$	99.2 lb.
Sulphur to slag = $853 \text{ lb.} \div 32 =$	26.6 lb.
Sulphur to slag =	72.6 lb.
Iron on charge for matte and slag =	933 lb.
Iron required by matte = $72.6 \text{ lb.} \times 2 =$	145 lb.
Iron for slag =	788 lb.
Iron required by silica = $853 \text{ lb.} \times 0.924 =$	788 lb.
Lime on charge =	534 lb.
Lime required by silica = $853 \text{ lb.} \times 0.625 =$	533 lb.
Excess of lime on charge over requirement =	1 lb.

This charge may be considered as satisfactory, and the finished charge will consist of D. and L. sinter 1000 lb., silicious ore mixture 1000 lb., pyrite cinder 985 lb., limestone 685 lb., and coke 515 lb. These are dry or net weights, and in those cases where the material contains a known amount of moisture the proper allowance must be made.

Requirement *b* in the statement of the problem asks for the wet weights of these materials to be used in an 8000 lb. charge. First let the wet weights of materials entering the charge as already determined be calculated, bearing in mind that the percentages of moisture specified in the analyses are based upon the wet weights. Hence

Wet weight =

$$\text{Dry weight} \times \frac{100}{100 - \text{per cent moisture on dry weight}}$$

The actual or wet weights required to form the charge as calculated above are as follows:

Material	Dry Weight	Wet Weight
D. and L. sinter	1,000 lb.	1,000 lb.
Silicious mixture	$1,000 \text{ lb.} \times \frac{100}{100 - 4.7} =$	1,050 lb.
Pyrite cinder	$985 \text{ lb.} \times \frac{100}{100 - 2.3} =$	1,010 lb.
Limestone	$685 \text{ lb.} \times \frac{100}{100 - 4.2} =$	715 lb.
Coke	515 lb.	515 lb.

The total of the wet weights exclusive of the coke is 3775 lb. and in order to determine the amount of each material to use in an 800 lb. charge it is simply necessary to multiply each by the factor

$$\frac{8000}{3775} = 2.12$$

Thus

D. and L. sinter	$= 1,000 \text{ lb.} \times 2.12 =$	2,120 lb.
Silicious mixture	$= 1,050 \text{ lb.} \times 2.12 =$	2,225 lb.
Pyrite cinder	$= 1,010 \text{ lb.} \times 2.12 =$	2,140 lb.
Limestone	$= 715 \text{ lb.} \times 2.12 =$	1,515 lb.
Total		8,000 lb.
Coke = 14 per cent of dry charge = $515 \text{ lb.} \times 2.12 =$		1,090 lb.

Requirement *c* in the statement of the problem asks for a calculation of the matte fall and the approximate composition of the matte, it being assumed that all of the copper on the charge will enter the matte, and that this together with iron, lead and sulphur will constitute 90 per cent of the matte produced. It is also assumed that the matte as produced will contain 23 per cent of sulphur and 46 per cent of iron.

For convenience in making these calculations let the last set of figures entered on the charge sheet be considered, i.e., the finished charge as it was determined in terms of dry weights. In balancing the charge the last time it was found that 72.6 lb. of sulphur would enter the matte. If this constitutes 23.0 per cent of the matte produced, the weight of matte from this charge will be

$$\frac{72.6 \text{ lb.}}{0.230} = 316 \text{ lb.,}$$

and the matte fall will be

$$\begin{aligned} \text{Weight of matte} \times 100 &= \frac{316 \times 100}{3670} \\ \text{Weight of charge producing matte} &= 8.61 \text{ per cent.} \end{aligned}$$

Now the amount of copper on the charge is as follows:

1,000 lb. D. and L. sinter $\times 0.0135 =$	13.5 lb.
1,000 lb. silicious ore mixtures $\times 0.0065 =$	6.5 lb.
985 lb. pyrite cinder $\times 0.0038 =$	3.7 lb.
Total =	23.7 lb.

Assuming that all of this copper will enter the matte, the matte will contain

$$\frac{23.7 \times 100}{316} = 7.5 \text{ per cent copper.}$$

If sulphur, copper, iron, and lead constitute 90.0 per cent of the matte, then the lead will be

$$90.0 - (23.0 + 46.0 + 7.5) = 90.0 - 76.5 = 13.5 \text{ per cent.}$$

So the matte as thus calculated will consist of

	Per Cent	Weight
Sulphur =	23.0 = 316 lb. $\times$ 0.230 =	72.6 lb.
Iron =	46.0 = 316 lb. $\times$ 0.460 =	145 lb.
Copper =	7.5 = 316 lb. $\times$ 0.075 =	23.7 lb.
Lead =	13.5 = 316 lb. $\times$ 0.135 =	42.6 lb.
Miscel. =	10.0 = 316 lb. $\times$ 0.100 =	31.6 lb.

Requirement *d* in the statement asks for a calculation of the bullion fall and a comparison of this with the per cent of lead on the charge. It is assumed that 4.0 per cent of the lead charged to the furnace is lost as dust and fume, that the slag will contain 0.70 per cent of lead, and that the base bullion produced will contain 97.0 per cent of lead.

The amount of lead on the charge is

1,000 lb. D. and L. sinter $\times$ 0.372 =	372 lb.
1,000 lb. silicious ore mixture $\times$ 0.0535 =	53.5 lb.
Total =	425.5 lb.

Hence the lead on the charge is

$$\frac{425.5 \times 100}{3670} = 11.6 \text{ per cent.}$$

The bullion fall is calculated by deducting the various amounts of lead that do not enter the bullion from that present. Thus

Lead lost to stack as dust and fume =	425.5 $\times$ 0.040 =	17.0 lb.
Lead entering matte =		42.6 lb.
Lead lost in slag = silica $\times$ 0.70 =	853 lb. $\times$ 0.0218 =	18.6 lb.
		78.2 lb.
Lead present on charge =		425.5 lb.
Lead to stack, matte and slag =		78.2 lb.
Lead entering bullion =		347.3 lb.

If this lead constitutes 97.0 per cent of the bullion produced, then the amount of bullion from this charge is

$$\frac{347.3 \text{ lb.}}{0.970} = 358 \text{ lb.,}$$

and the bullion fall is

$$\frac{358 \times 100}{3670} = 9.75 \text{ per cent.}$$

In concluding this problem it should be remarked that the calculation of matte composition in advance is not, as a rule, a very practicable or necessary operation. It is given here, together with the bullion calculation, more as an exercise to bring before the student certain facts as to matte and bullion constitution, lead losses, etc., than for any other reason. It is true, however, that the converse of such calculations have frequent application, *i.e.*, the matte, slag, and bullion analyses with their respective production figures are employed in calculations to determine and check the metal losses incidental to the operation. This point will be illustrated in the solution of the next problem.

In the problem just completed the calculations involved, when moisture, manganese, and magnesia are taken into consideration, have been illustrated. For this reason these factors will not be introduced again, and analyses that have presumably been already simplified and are stated in terms of dry weights will be employed hereafter.

PROBLEM III

Materials of compositions shown in the following table are to be smelted in the lead blast furnace.

Material	Lead, Per Cent	Silica, Per Cent	Iron, Per Cent	Lime, Per Cent	Sulphur, Per Cent
D. and L. sinter	39.50	17.5	20.6	12.5	4.25
Silicious ore	12.30	50.1	10.7	2.3	5.33
Iron ore	0.0	12.6	55.3	1.7	1.94
Limestone	0.0	7.5	4.2	46.8	0.0
Coke	0.0	5.2	1.2	1.1	1.32

Conditions and assumptions.—It is desired to have

12.0 per cent of lead on the finished charge, *i.e.*, the two lead bearing materials are to be so proportioned that 12.0 per cent of the charge including iron ore and limestone, but not including coke, will consist of lead.

It is desired to produce a slag that will contain silica 34 per cent, ferrous oxide 28 per cent, and lime 28 per cent, leaving 10 per cent to be formed by the minor constituents.

The amount of coke is to be 14 per cent of the charge.

Assume that 20 per cent of the sulphur charged to the furnace will escape with the gases, that the slag produced will analyze 1.0 per cent of sulphur, and that the remaining sulphur will form matte containing 23.0 per cent of sulphur and 46.0 per cent of iron.

Assume that when this furnace charge as calculated is actually smelted the matte fall is found to agree with the calculated figure, and an analysis of the matte shows a 12.5 per cent lead content.

Assume that the amount of bullion produced from the charge is 10.3 per cent, and that it shows on analysis 97.0 per cent of lead.

Assume that the slag as produced contains 0.68 per cent of lead.

Required.—(a) Determine the amounts of silicious ore, iron ore, limestone, and coke to be smelted with 1000 lb. of the D. and L. sinter in order to comply with the above outlined conditions.

(b) Calculate the distribution of the lead on the charge among the various products formed, bullion, matte, slag, and flue loss.

Notes.—The condition imposed in this case, that the charge shall contain a definite amount of lead, is one that is frequently encountered in districts where silver-lead smelters have offerings of considerable quantities of low-lead, silicious ores. In such cases ores that are rich in lead are valuable not only for the metal itself, but the lead in such materials may serve as a collector for silver and gold occurring in ores that contain little or no lead. In other words, the ore that is rich in lead is diluted with such a quantity of ore that is low in lead as it will take, and still maintain a given quantity of lead on the furnace charge.

In this case it is required that 12.0 per cent of lead be present, although this does not represent the minimum that might be successfully employed.

There are several methods whereby this problem might be solved. One of the most obvious, and the one that will be here employed, consists of making two separate calculations, the first involving 1000 lb. of the D. and L. sinter with the necessary fluxes and coke, the second involving a like amount of the silicious ore with its necessary fluxes and coke. Thus two charges will be calculated and subsequently combined in the manner required to make lead 12.0 per cent of the final charge.

Solution.—Again the logical starting point is the calculation of the slag ratios, and again a unit weight of silica will be taken as the standard. In a slag of the desired composition the amounts of other constituents present with each pound of silica will be:

Iron =	$\frac{28\% \text{ FeO}}{34\% \text{ SiO}_2} \times \frac{7}{9}$ (ratio of Fe to FeO) =	0.640 lb.
Lime =	$\frac{28\% \text{ CaO}}{34\% \text{ SiO}_2} =$	0.824 lb.
Sulphur =	$\frac{1.0\% \text{ S}}{34\% \text{ SiO}_2} =$	1/34 lb.

A charge sheet may now be drawn up according to the following form. The first charge to be calculated involving 1000 lb. of D. and L. sinter will hereafter be designated as Charge A, while the second one involving 1000 lb. of the silicious ore will be designated as Charge B.

CHARGE SHEET, PROBLEM III

CHARGE A.

	Material	Dry Weight	Silica		Iron		Lime		Sulphur	
			Per Cent	Wt.	Per Cent	Wt.	Per Cent	Wt.	Per Cent	Wt.
a	D. & L. sint.	1,000	17.5	175	20.6	206	12.5	125	4.25	42.5
b	Silicious ore	115	50.1	58	10.7	12	2.3	3	5.38	6.2
c	Limestone	170	7.5	12	4.2	7	46.3	80	0.0	0.0
d	Coke	180	5.2	9	1.2	2	1.1	2	1.32	2.4
e	First trial totals			354		227		210		51.1
f	D. & L. sint.	1,000		175		206		125		42.5
g	Silicious ore	105		53		11		2		5.7
h	Limestone	160		11		7		75		2.3
i	Coke	177		9		2		2		
j	Second trial totals			248		226		204		50.5

CHARGE B.

	Material	Dry Weight	Silica		Iron		Lime		Sulphur	
			Per Cent	Wt.	Per Cent	Wt.	Per Cent	Wt.	Per Cent	Wt.
k	Silicious ore	1,000	50.1	501	10.7	107	2.3	23	5.38	53.8
l	Iron ore	640	12.6	82	55.3	354	1.7	11	1.9	12.6
m	Limestone	1,125	7.5	83	4.2	47	46.8	526	0.0	0.0
n	Coke	388	5.2	20	1.2	5	1.1	4	1.32	5.1
o	First trial totals			686		518		564		71.5
p	Silicious ore	1,000		501		107		23		53.8
q	Iron ore	640		81		354		11		12.4
r	Limestone	1,125		83		47		526		0.0
s	Coke	387		20		5		4		5.1
t	Second trial totals			685		513		564		71.3

In calculating Charge A the first thing to enter is 1000 lb. of the D. and L. sinter, together with the amounts of its constituents, in line *a*. Now before entering any further analyses it will be well to consider the figures in line *a* and find out what further materials are needed to complete the charge. From the figures in line *a*,

Sulphur to matte and slag = 42.5 lb. $\times$ 0.80 =	34.0 lb.
Sulphur to slag with silica = 175 lb. $\div$ 34 =	5.2 lb.
Sulphur to matte after deducting gas and slag losses =	28.8 lb.
Iron present for matte and slag =	206 lb.
Iron to matte with sulphur = 28.8 lb. $\times$ 2 =	58 lb.
Iron available for slag =	148 lb.
Iron required by silica = 175 lb. $\times$ 0.64 =	112 lb.
Iron excess over silica in 1,000 lb. D. and L. =	36 lb.

This is a new situation. The principal material in Charge A has an excess of iron over that required by its silica and sulphur to form slag and matter. Therefore iron ore will not be needed on this charge, but there is need for a silicious material. The logical thing to use under these circumstances is some of the silicious ore that is to be smelted. The next question is, how much?

In order to estimate the amount of the silicious ore that will be required by the D. and L. sinter it is necessary to consider the amounts of iron, silica, and sulphur in the former. The analysis shows

Sulphur to matte and slag = 5.38 per cent $\times$ 0.80 =	4.30 per cent
Sulphur to slag = 50.1 per cent $\div$ 34 =	1.47 per cent
Sulphur to matte =	2.83 per cent
Iron present =	10.7 per cent
Iron to matte = 2.83 per cent $\times$ 2 =	5.7 per cent
Iron for slag =	5.0 per cent
Silica present =	50.1 per cent
Silica to slag with iron = 5.0 per cent $\div$ 0.640 =	7.8 per cent
Silica in excess of iron =	42.3 per cent

It has been shown that 1000 lb. of D. and L. sinter contains 36 lb. of iron in excess of silica, and if silica for this iron is to be supplied from the silicious ore, which has 42.3 per cent of silica in excess of iron, then the amount of silicious ore required will be

$$\frac{36 \text{ lb. of iron}}{42.3} \times 100 = 133 \text{ lb.}$$

This then would provide the correct amount of silica for the D. and L. sinter, but the analyses of the limestone and coke show that both of these materials contain silica in excess of iron. Therefore 133 lb. of the

silicious ore would provide an excess of silica on the finished charge. For the first trial a smaller amount should be used, say 115 lb. Enter it in line *b* of the charge sheet, entering also the amounts of the constituents of this material in their proper places.

An estimate of the limestone may now be made, taking into account the silica and lime shown in lines *a* and *b*.

Lime required by 233 lb. silica = 233 lb. $\times$ 0.824 =	192 lb.
Lime present in lines <i>a</i> and <i>b</i> =	128 lb.
Lime to be supplied =	64 lb.

In the limestone the 7.5 per cent of silica will require $7.5 \times 0.824 = 6.2$ per cent of the lime, and this leaves $46.8 - 6.2 = 40.6$ per cent of lime in excess of the silica. The amount of limestone required to provide 64 lb. of available lime will therefore be

$$\frac{64 \text{ lb.}}{0.406} = 158 \text{ lb.}$$

But this will be insufficient for the entire charge, because the coke is not included in making this estimate, and the coke analysis shows an excess of silica over lime. For the first trial, therefore, let this amount of limestone be raised to 170 lb. Enter this together with its calculated constituents in line *c*.

The coke for the charge as thus determined will be $(1000 + 115 + 170) \text{ lb.} \times 0.14 = 1285 \text{ lb.} \times 0.14 = 180 \text{ lb.}$ Enter this amount of coke in line *d*, calculating its constituents.

The totals of silica, iron, lime, and sulphur are now entered in line *e*, and the charge is tested as follows. From amounts in lines,

Sulphur to matte and slag = 51.1 lb. $\times$ 0.80 =	40.9 lb.
Sulphur to slag = 254 lb. $\div$ 34 =	7.5 lb.
Sulphur to matte =	33.4 lb.
Iron on charge for matte and slag =	227 lb.
Iron to matte = 33.4 lb. $\times$ 2 =	67 lb.
Iron for slag =	160 lb.
Iron required by silica = 254 lb. $\times$ 0.640 =	163 lb.
Deficit of iron =	3 lb.
Lime on charge for slag =	210 lb.
Lime required by silica = 254 lb. $\times$ 0.824 =	209 lb.
Excess of lime =	1 lb.

The charge as it stands shows a deficit of iron amounting to 3 lb. and an excess of lime amounting to 1 lb. While this would not be a serious matter in practice, for the present purpose it will be better to correct the condition. The desired change may be effected by cutting the amount of silicious ore on the charge. It will be recalled that this material contains about 42 per cent of silica in excess of iron. The removal of 10 lb. of it from the charge will therefore decrease the amount of free silica by about 4 lb., and this according to the slag ratio will correct the deficit of iron. At the same time a decrease in the silica will destroy the balance of the charge with respect to lime. Consequently, a cut in the limestone will also have to be made. Reasoning in a manner similar to the above shows that this cut should also be about 10 lb.

For the second trial enter 1000 lb. of D. and L. sinter in line *f*, 105 lb. of silicious ore in line *g*, 160 lb. of limestone in line *h*, and 177 lb. of coke in line *i*. The components are to be calculated as usual, totals being entered in line *j*.

Considering these totals,

Sulphur to matte and slag = 50.5 lb. $\times$ 0.80 =	40.4 lb.
Sulphur to slag = 249 lb. $\div$ 34 =	7.3 lb.
Sulphur to matte =	33.1 lb.
Iron for matte and slag =	226 lb.
Iron to matte = 33.1 lb. $\times$ 2 =	66 lb.
Iron for slag =	160 lb.
Iron required by silica = 248 lb. $\times$ 0.640 =	159 lb.
Excess of iron =	1 lb.
Lime on charge for slag =	204 lb.
Lime required by silica = 248 lb. $\times$ 0.824 =	204 lb.

This works out a little better than the previous trial, though both of them are good, and either would be sufficiently correct.

The amount of lead on Charge A as it was last calculated is

Lead from 1,000 lb. D. and L. sinter = 1,000 lb. $\times$ 0.2950 =	395.0 lb.
Lead from 105 lb. silicious ore = 105 lb. $\times$ 0.123 =	12.9 lb.
Total =	408 lb.

$$\text{Per cent of lead on Charge A} = \frac{408 \times 100}{1265} = 32.5.$$

Passing now to the calculation of Charge B, the first step consists of entering 1000 lb. of the silicious ore on the charge sheet. It is seen in line *k* with the amounts of its constituents properly entered.

The amount of silica present in this material in excess of iron has already been estimated at 42.3 per cent. Hence, in the 1000 lb. there will be 423 lb. of silica to be provided with iron. Considering the iron ore analysis, the 12.6 per cent of silica will require $12.6 \times 0.640 = 8.1$ per cent of iron. The 1.94 per cent of sulphur present will require about 2 per cent of iron for matte. There remains $55.3 - 10.1 = 45.2$ per cent approximately of iron in excess of the silica and sulphur. The iron ore required for 423 lb. of silica in the silicious ore will therefore be

$$\frac{423 \text{ lb.} \times 0.640}{0.452} = 599 \text{ lb.}$$

As in most of the previous cases, however, this amount of iron ore will not be sufficient for the entire charge, because the limestone and coke are both yet to be added, and both contain an excess of silica over iron. As a first trial let the amount of iron ore be increased beyond this estimate to 650 lb. Enter this amount with its constituents in line *l*.

Now, consider the amounts of silica and lime in lines *k* and *l*.

Lime required by 583 lb. silica = 583 lb. $\times$ 0.824 =	480 lb.
Lime present =	34 lb.
Lime to be supplied =	446 lb.

It has already been seen that the limestone contains 40.6 per cent of lime in excess of silica. Hence the limestone required to provide 446 lb. of lime is

$$\frac{446 \text{ lb.}}{0.406} = 1100 \text{ lb.}$$

What is to be done with this? Shall 1100 lb. of limestone be entered on the charge sheet? No, because the coke contains silica in excess of lime, and this amount of limestone would prove insufficient for the entire charge. Let it be increased to 1125 lb. Enter this in line *m* with its calculated constituents.

Coke for this charge will be: $(1000 + 650 + 1125) \text{ lb.} \times 0.14 = 2775 \text{ lb.} \times 0.14 = 388 \text{ lb.}$ Enter this amount and constituents in line *n*.

Considering the totals of line *o*,

Sulphur to matte and slag = 71.5 lb. $\times$ 0.80 =	57.3 lb.
Sulphur to slag = 685 lb. $\div$ 34 =	20.2 lb.
Sulphur to matte =	37.1 lb.
Iron on charge for matte and slag =	518 lb.
Iron to matte = 37.1 lb. $\times$ 2 =	74 lb.
Iron to slag =	144 lb.
Iron required by silica = 686 lb. $\times$ 0.640 =	439 lb.
Excess of iron on charge =	5 lb.
Lime on charge for slag =	564 lb.
Lime required by silica = 686 lb. $\times$ 0.824 =	565 lb.
Deficit of lime =	1 lb.

The excess of iron amounting to 5 lb. may be adjusted by cutting 10 lb. from the iron ore. The limestone may be left as it is, because this cut in the iron ore will naturally adjust the 1 lb. deficit of lime by removing silica from the charge.

Amounts for the second trial will therefore be silicious ore 1000 lb., iron ore 640 lb., limestone 1125 lb., and coke (14 per cent) 387 lb. Enter these in lines *p*, *q*, *r*, and *s*, with totals in line *t*.

Considering the totals in the last line,

Sulphur to matte and slag = 71.5 lb. $\times$ 0.80 =	57.0 lb.
Sulphur to slag = 685 lb. $\div$ 34 =	20.1 lb.
Sulphur to matte =	36.9 lb.
Iron on charge for matte and slag =	513 lb.
Iron to matte = 36.9 lb. $\times$ 2 =	74 lb.
Iron to slag =	439 lb.
Iron required by silica = 685 lb. $\times$ 0.640 =	438 lb.
Excess of iron =	1 lb.
Lime on charge for slag =	564 lb.
Lime required by silica = 685 lb. $\times$ 0.824 =	564 lb.

The charge is satisfactorily balanced.

The amount of lead on Charge B as last calculated is lead from 1000 lb. silicious ore = $1000 \text{ lb.} \times 0.1230 = 123 \text{ lb.}$

$$\text{Per cent of lead on charge} = \frac{123 \times 100}{2765} = 4.45$$

Requirement *a* in the statement of the problem asks for the amounts of silicious ore, iron ore, limestone, and coke to be smelted with 1000 lb. of the D. and L. sinter in order to have present 12.0 per cent of lead on the charge. The per cent of lead on Charge A is 32.5, and that on Charge B is 4.45. In what proportions will A and B have to be mixed to have 12.0 per cent of lead present in the mixture?

Let *a* = the per cent of Charge A in such a mixture and *b* = the per cent of Charge B in the mixture.

Then

$$a + b = 100$$

and

$$0.325a + 0.0445b = 12.0.$$

Solving, *a* = 26.8 per cent, and *b* = 73.2 per cent.

The weight of Charge A as calculated is 1265 lb. This contains 1000 lb. of the D. and L. sinter. Hence the final charge will weigh

$$\frac{1265 \text{ lb.}}{0.268} = 4720 \text{ lb.,}$$

it being necessary to have 26.8 per cent of Charge A in order that the lead may be 12.0 per cent of the charge. Of Charge B there will be required for the final charge 4720 lb. — 1265 lb. = 3455 lb. Since Charge B as calculated weighed 2765 lb., the amount of each material therein to be employed in the final charge may be found by multiplying the original figures by

$$\frac{3455}{2765} \quad 1.25$$

Thus

Silicious ore, 1,000 lb. $\times$ 1.25 =	1,250 lb.
Iron ore, 640 lb. $\times$ 1.25 =	800 lb.
Limestone, 1,125 lb. $\times$ 1.25 =	1,405 lb.

The final combination of Charges A and B will therefore be as follows:

D. and L. sinter =	1,000 lb.
Silicious ore, 1,250 lb. =	1,355 lb.
Iron ore =	800 lb.
Limestone, 1,405 lb. =	1,565 lb.
Total =	4,720 lb.
Coke = 14 per cent of charge =	660 lb.

Requirement *b* in the statement of the problem asks for a calculation of the lead distribution among the various products formed during the smelting operation. These conditions are assumed, that the amount of matte produced is found to agree with the calculated matte fall, that the matte contains 12.5 per cent of lead, that the amount of bullion produced is 10.3 per cent of the charge and contains 97.0 per cent lead, and that the slag produced contains 0.68 per cent lead.

In order to solve this part of the problem it is neces-

sary to employ the final charge as outlined above. The information needed may be conveniently assembled in the following form:

Material	Weight, lb.	Lead, lb.	Silica, lb.	Sulphur, lb.
D. and L. sinter.....	1,000	395	175	42.5
Siliceous ore.....	1,355	167	679	72.9
Iron ore.....	800	...	101	15.5
Limestone.....	1,565	...	117	...
Coke.....	660	...	34	8.1
		562	1,106	139.6

The above total figures yield the following:

Sulphur to matte and slag = $139.6 \text{ lb.} \times 0.80 =$	111.5 lb.
Sulphur to slag = $1106 \text{ lb.} \div 34 =$	32.5 lb.
Sulphur to matte =	79.0 lb.

If this sulphur constitutes 23.0 per cent of the matte, then the amount of matte produced from the charge is

$$\frac{79.0 \text{ lb.}}{0.230} = 343 \text{ lb.}$$

Lead contained in the matte = $343 \text{ lb.} \times 0.125 =$	42.9 lb.
Lead in slag = $1,106 \text{ lb.} \times \frac{34}{0.68}$ (ratio lead to silica) =	22.1 lb.
Lead in bullion = $4,720 \text{ lb.} \times 0.103 \times 0.970 =$	472 lb.
Lead accounted for =	537 lb.
Lead loss to stack = $562 \text{ lb.} - 537 \text{ lb.} =$	25 lb.

The distribution of the lead is therefore

Product	Lead, lb.	Per Cent
Bullion.....	472	84.1
Matte.....	42.9	8.5
Slag.....	22.1	3.9
Dust, fume, etc.....	25	4.5

CONCLUSION

The practising lead metallurgist, if he ever takes the time to look through these problems, will no doubt find much in them that is open to criticism. To all sins of omission or commission that may be thus disclosed the writer pleads guilty in advance. It is not with the intention of instructing the metallurgist in his business that these problems have been presented, but rather to fix in the mind of the student a few facts concerning charge calculations and the metallurgy of lead, which, without actual practice with numerical examples, he frequently fails to grasp.

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The Recovery of Benzol from Gas*

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One of the most noteworthy achievements in American chemical industry during these last two eventful years has been the rapid development of the recovery of benzol from coal gas. Associated principally with the manufacture of by-product coke, the business of recovering benzol in this country had previously lagged behind the parent industry which was already beginning to make striking progress three or four years before the outbreak of the great war. The lag was due, partly, to a seeming lack of real demand for the material; partly to the abundance of petroleum, and partly, also, to the groundless fear that the operations necessary for the recovery of benzol would add too many complications to the manufacture of by-product coke.

Thus, at the close of 1913 there were about sixteen plants in the United States making light oil from coke-oven gas. Most of the product from these plants was used for the enrichment of illuminating gas, leaving a comparatively small amount of material for other purposes. There were only two or three small plants for the manufacture of pure benzene, toluene, etc.

Even at that time, however, there were signs that the importance of the recovery of benzol was gaining

recognition, and it is likely that the advancing price of gasoline would soon have led to a large extension of the industry even without the stimulus of war prices.

From the close of 1914 to the summer of 1915 the prices of benzol products rose with the cessation of foreign supply and the ever increasing necessities of the munition business, until pure benzene commanded over 80 cents per gallon and toluene was sold as high as \$7.00 per gallon. The response was rapid. The first complete modern plant for the large-scale production of pure benzene and toluene was put into operation in May, 1915, and the total production of benzol products in the United States in that year rose to over twenty-two million gallons—more than twice as much as had been produced the previous year.

At present writing (January 1, 1917) there are about forty benzol recovery plants in operation in connection with by-product coke plants, having a capacity of approximately thirty million tons of coal per annum. Making due allowance for the facts that a number of these plants scrub only part of their gas and that part of the benzol is immediately used for enrichment, a conservative estimate would place the present annual light oil production at not less than forty million gallons. Three of these plants are now being enlarged, and eight new plants are in course of construction. The completion of this new work will bring the annual production of light oil up to nearly fifty million gallons.

The prices of benzene and toluene, although lower than the abnormal figures of two years ago, are still firm, the former at about 55 cents per gallon and the latter at about \$1.75 to \$2.50 per gallon.

It is to be especially noted that the increase of output has been almost altogether in the production of pure products; the amount of unrefined benzol now being made is probably actually less than was made in 1914. It appears probable that at least 80% of the present production is redistilled for the preparation of pure benzene and toluene.

USES OF BENZOL

The question is frequently asked: "What will become of this vast production of benzol after the war?" It must be remembered, in the first place, that the use of the benzol group of explosives, particularly trinitrotoluol and tetranitroaniline, is by no means confined to military purposes, and their consumption for commercial blasting operations will doubtless increase to a very large extent, because the war has given such a convincing demonstration of their superior qualities. The demand for military explosives is likely to continue on a considerably greater scale than before the war on account of the increased amount of military training that is being required in every country, and on account of the general recognition of the wisdom of accumulating and storing large reserve supplies of the principal explosives. It is one of the peculiar merits of trinitrotoluol that it can be stored indefinitely without risk of deterioration, and the importance of conserving this valuable asset in national defense cannot be overestimated.

The vast development of American chemical industries insures a market for large quantities of benzol products to be used for synthetic purposes. Benzene, itself, is an indispensable source of nitrobenzene and aniline with its long series of valuable derivatives. The manufacture of synthetic phenol, which is far outstripping that of carboic acid made directly from coal tar, may be considered as a very important outlet for pure benzene on account of the great increase in the production of the various condensation products of phenol and formaldehyde. From toluene we obtain such well

*A paper read before the American Institute of Chemical Engineers, New York City, Jan. 12, 1917.

known products as benzaldehyde, saccharin and benzoic acid. Metaxylene is the source of a rather important series of dyes. The study of the other materials contained in smaller amounts in coke oven benzol and available for the production of many interesting series of synthetic chemicals has barely begun, but promises to afford striking results in the not far distant future.

Passing thus briefly over the consumption of benzol in the chemical industries, let us consider its employment as motor fuel. So far as bulk is concerned this bids fair to surpass any other possible source of demand. Previous to the war, Germany used over 50% of its benzol production for the operation of internal combustion engines. J. S. Critchley, president of the British Institution of Automobile Engineers, is quoted as stating that the carburetion of benzol presents no difficulties and that in actual practice the material gives an increase of mileage of about 20% over gasoline, affording at the same time 12 to 15 per cent more power. A series of tests made in 1913 at Brooklands, England (*Gas World*, Sept. 6, 1913, Coking and By-Product Section, page 9), showed an average of five miles increase per gallon.

The demands of the automobile industry alone are so great as to preclude the possibility of any destructive competition between benzol and gasoline. As was stated early in this paper the benzol recovery plants now in course of construction, together with those already operating, will make an annual production of about fifty million gallons of benzol. There are now over two million automobiles in operation in this country so that the contemplated benzol production would give each machine about 25 gallons. If all the coke that the country now requires were coked in by-product ovens with benzol recovery apparatus we should expect a total annual benzol production of about 110 million gallons or 55 gallons per machine. This total benzol production would be less than half the amount of gasoline and naphtha exported in 1915.

Other uses of benzol may be rapidly summarized for sake of completeness. Quantities are employed in the manufacture of paints, stains, varnishes and lacquers; in the cleaning industry; in the extraction of grease and fats; as solvents for rubber and for the manufacture of artificial leather and insulating materials. Lastly may be mentioned one use which should be considered rather as an economic waste than of benefit to the industry. This is for enriching illuminating gas to make it conform with antiquated candle power standards based on the use of flat flame burners. The utilization of mantle burners and the increasing tendency to replace old candle power specification by calorific standards, already universally adopted in more advanced European practice, will doubtless soon do away with the necessity for gas enrichment, and make it possible for large illuminating gas plants to recover their benzol and utilize it for more rational purposes.

PRINCIPAL OF BENZOL RECOVERY PROCESS

Before proceeding with the technical description of the benzol recovery process it may be well to give a few moments' consideration to the gas from which the material is extracted. The gases produced by the high-temperature distillation of coal are extremely complex in composition, but we may consider their constituents as grouped in two classes, viz., easily condensable and difficultly condensable substances, the former solid liquid or very soluble in water at ordinary temperatures, the latter gaseous and difficult to liquefy. Most of the substances of the first group such as water, ammonia, and the heavy hydrocarbons of tar, are removed by the usual operations of condensation and treatment with fresh water or acid. The amount and nature of the

easily condensable substances left in the gas after undergoing these operations depends upon the vapor tension of each. Substances of a relatively high vapor tension such as benzene and toluene remain, to a large extent, uncondensed. Only 5% of the total benzol in the gas is removed with the tar in the condensing plant. Actually, of course, the gas after leaving the plant, contains slight amounts in the form of vapor, of all the original condensable substances, but the quantities of substances having higher boiling points than that of naphthalene (218° C.) are practically negligible.

Exclusive of water, the easily condensable vapors remaining in ordinary coke oven gas after the usual process of condensation and ammonia recovery, amount to about 1% by volume of the gas. They might be removed by cooling the gas to a very low temperature and this was actually done on a large scale in Europe some years ago, but the method was handicapped by mechanical difficulties largely due to the separation of ice and has been altogether abandoned. The only practical alternative which can be employed to recover these vapors, without altering their chemical constitution, is to treat the gas with a medium in which the vapors are soluble and from which they may be recovered by simple distillation.

This is the principle of every benzol recovery process in operation at the present time. It appears to have been first employed in 1859 by Vogel, who washed coal gas with fatty oils for recovering the benzol. It is peculiar that Vogel had only the idea of enriching these oils so as to improve their quality for illuminating purposes. Various processes for extracting benzol based on this principle were later patented; but it was not until 1887 that it was put into successful commercial operation. This was done in Germany by F. Brunk, who is generally acknowledged as being the founder of the modern benzol recovery industry.

It is a peculiar circumstance that the condensable hydrocarbon vapors belong almost entirely to the aromatic series. Benzene together with its homologues, toluene and the xylenes constitutes over 85%. Other substances present in much smaller amounts are carbon disulphide, thiophene, pyridine, naphthalene, and various olefines of both cyclic and open chain structure. Members of the paraffin series of hydrocarbons are almost entirely absent. The mode of formation of these compounds in the destructive distillation of coal, the effect of various conditions of carbonization, such as temperature and rate of heating on the character and amounts of the various substances formed, and the variation in the quality and quantity of the products from different groups of coals, are subjects of extreme interest on which our conceptions are not yet by any means clearly defined. The most important generalization that we are able to make is that the maximum yields of benzene and toluene are obtained at moderate coking temperatures. Higher temperatures have a tendency to form more benzene apparently at the expense of the toluene and extremely high temperatures decrease the yields of both benzene and toluene.

The percentages of the more important constituents of typical coke oven light oil and the amounts usually produced per ton of coal 2000 lbs. are given herewith:

TABLE I—AVERAGE COMPOSITION OF COKE OVEN LIGHT OIL	
	Per Cent in Light Oil Gallons per Ton Coal
Benzene	66 1.782
Toluene	15 0.405
Xylene	8 0.216
Other substances	11 0.297
(principally hydrocarbons)	
Total	100 2.700

For sake of convenience a table of the more important properties of some of the constituents of light oil is also inserted. In the preparation of this table the literature has been exhaustively investigated and every endeavor has been taken to present the data as accurately as possible.

TABLE II
 Compiled by the Laboratory of the H. Koppers Company, Mellon Institute, Pittsburgh, Pa.
 Carbon Disulphide Benzene Toluene M-Xylene Naphthalene

Formula (Molecular)	Data	Ref.	Data	Ref.	Data	Ref.	Data	Ref.	Data	Ref.
Molecular Wt. (16)	76.12	1	78.05	1	92.06	1	106.08	1	128.06	1
Lbs. per U. S. gal. (60°F)	10.57	2	7.36	3	7.27	8	7.26	8	9.60	5
Sp. Gr. (0°C/4°C)	1.2921	22	0.8999	3	0.8845	4	0.8823	8	.....	11
Sp. Gr. (10°C/4°C)	1.2773	2	0.8893	3	0.8757	8	0.8735	8	.....	11
Sp. Gr. (15°C/4°C)	1.2688	2	0.8839	3	0.8714	8	0.8697	8	1.1517	5
Sp. Gr. (20°C/4°C)	1.2623	2	0.8786	3	0.8659	3	0.8655	6	.....	11
Sp. Gr. (30°C/4°C)	1.2473	2	0.8679	3	0.8573	8	0.8574	8	.....	11
Expansion Coefficient (°C)	0.00125	2	0.0012	7	0.0010	7	0.00095	7	.....	11
Boiling Pt. (760 mm Hg.)	46.3	1	50.36	12	110.3	13	139.1	13	217.7	1
Increase in B.P. (°/mm Hg.)	0.041	14	0.043	15	0.047	15	0.052	15	0.059	16
Vapor Pressure mm Hg. (0°C)	127.9	14	26.63	18	7.20	18	1.75	18	0.022	9
Vapor Pressure mm Hg. (10°C)	198.5	14	45.68	18	13.02	18	3.45	18	0.047	9
Vapor Pressure mm Hg. (15°C)	244.1	14	58.90	18	17.22	18	4.74	18	0.062	9
Vapor Pressure mm Hg. (20°C)	298.0	14	75.21	18	22.53	18	6.43	18	0.080	9
Vapor Pressure mm Hg. (30°C)	434.6	14	119.34	18	37.45	18	11.43	18	0.135	9
Lbs. per cu. ft. vapor. (60°F-30°F)	0.202	10	0.209	10	0.244	19	0.281	19	0.339	20
Kg. per cbm. Vapor (0°C-75° mm.)	3.42	10	3.54	10	4.14	19	4.76	19	5.72	20
Heat Combustion (Net)										
15°C = 760 mm Hg.										
Cal. per Kg. liquid	3,480	10	9,960	17	10,150	17	10,230	17	9,700	17
Cal. per Liter liquid	4,420	10	8,805	21	8,250	21	8,910	21	11,170	21
B.t.u. per lb. liquid	6,260	21	17,920	21	18,270	21	18,410	21	17,460	21
B.t.u. per U. S. gal. liquid	66,100	21	132,100	21	132,600	21	133,500	21	167,300	21
Cal. per cu. m. vapor	11,550	21	33,600	21	40,150	21	46,500	21	52,400	21
B.t.u. per cu. ft. vapor	1,300	21	3,780	21	4,500	21	5,210	21	5,910	21
Sp. Heat (Cal. per Kg.)	0.240	23	0.419	24	0.440	24	0.383	25	0.314	26
Heat Vaporization (Cal. per Kg.)	83.3	27	92.9	27	83.55	28	78.25	28	.....	11
Solubility in Water (22°C)										
Gms. substance in 100 gm. H ₂ O	0.219	22	0.072	22	Insol.	1	Insol.	1	Insol.	1
Gms. H ₂ O in 100 gm. substance	0.765	22	0.241	22	Insol.	1	Insol.	1	Insol.	1
Melting Point (°C)	-108.6	1	+5.4	1	-92.4	1	-54.8	1	+30.0	1

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Note.—References, are, in many cases, to the fundamental data from which constants were calculated, i.e., (2) refers to relative volume data. (10) was computed from vapor density, molecular heat, etc.

OPERATION OF A BENZOL RECOVERY PLANT

In discussing the operation of a benzol recovery plant of modern type I shall deal principally with the Koppers patented process, because I have made a rather special study of this process as being typical of modern practice. To the best of my knowledge all of the coke oven benzol plants now under construction in America, with possibly one or two exceptions, are of this type.

In America the wash oil generally used to absorb the benzol is a petroleum product usually known as straw oil, of which at least 90% should distil between 250 and 350° C. A good absorbent oil has a specific gravity of less than 0.88 at 15° C. and is readily fluid at 4° C. It contains no naphthalene or pitch and exerts a good solvent action on benzol. In best practice the amount of benzol absorbed (technically the "enrichment") is kept between 2 and 3% of the absorbing oil. Too high enrichment is likely to lead to loss of benzol and too low enrichment may involve needless consumption of absorbing oil. In European practice heavy tar oils used almost exclusively as absorbing and steam media and such materials may find increasing application in America. Such tar oils should contain less than 7% naphthalene and 90% of the material should distil between 200 and 300° C.

Fig. I shows a flow sheet of a benzol plant showing the principal features of operation. Let us follow first

the course of the gas and then that of the oil. Previous to treatment with the absorbing oil, the gas should be cooled to a suitable temperature which may vary from plant to plant and depends principally upon such factors as its moisture and naphthalene content, temperature of the wash oil, and percent enrichment desired. This cooling is accomplished by means of the cooler (A), which is preferably of the direct contact type. The water not only acts as a cooling medium, but mechanically washes a large portion of the naphthalene out of the gas and carries it into the separating sump (B). The cool gas then passes into the benzol washers (C). These are tall scrubbing towers of the hurdle type, effecting a very intimate and prolonged contact between gas and oil. The debenzolized gas passes out of the last washer through the return main to its point of consumption.

The fresh wash oil is pumped from the circulating tank (D) over the scrubbers in an opposite direction to the flow of the gas, maintaining the counter-current principle that should be adopted in nearly all scrubbing operations and bringing the fresh washing medium into the scrubbing system at a point where the gas contains the least light oil vapors. The distribution of the wash oil over the tops of the scrubbers is a very important matter, and should be done as uniformly as possible. The enriched wash oil accumulates in tanks usually located underneath the scrubbers, and is pumped from these to the benzol recovery plant to be heated for the purpose of releasing its benzol constituents.

Part of this heating is accomplished in the Koppers System by the utilization of the heat in the hot debenzolized wash oil leaving the still. Two heat economizers are used in this system. The cold oil first enters the heat exchanger (E), where it is heated by benzol vapors and steam from the still (H), thence it is conducted to a second heat exchanger (F), where it receives additional heating by means of hot debenzolized wash oil leaving the still (H). It is then still further heated to the maximum temperature desired by means of live steam in a superheater (G), from which it passes into still (H), this still is composed of a series of superimposed sections or chambers as in common distillation practice. The heated oil flows down through these sections while steam is blown directly into the lowest section and travels in a direction opposite to that of the oil. The mixture of benzol and water vapor is partially rectified in the upper portion of the still, and then enters the heat exchanger (E) as mentioned be-

ferent boiling points preliminary to washing and final rectification. This and subsequent distillations are made intermittently in stills of large capacity (6000 to 12,000 gal.), which give better fractionations than are possible in smaller apparatus. The continuous type of stills has not been found satisfactory in this work. The crude still does not require the elaborate dephlegmator, that is necessary on the final rectifying stills. The heating is accomplished by means of internal steam coils and a direct steam spray. The benzol and toluol are principally distilled off by indirect heat, using the steam coils, and the higher boiling constituents xylol, solvent naphtha, etc., are then distilled over by introducing steam directly into the still.

After the benzol, toluol, xylol and solvent naphtha have been distilled off, a certain amount of wash oil containing naphthalene remains in the still tank. The presence of wash oil in the light oil is due not only to mechanical trapping of the heavy oil during the distillation, but also to the actual distillation of some of its original constituents by agency of the direct steam used. The products recovered from 1000 gal. of light oil vary according to the kind of coal coked, the regulation of the ovens and the method of operation of the light oil plant. In one plant that may be taken as fairly typical of a well-operated system the yields average about as follows:

From 1000 gal. crude light oil.
680 gal. crude benzol.
140 gal. crude toluol.
50 gal. crude xylol.
55 gal. solvent-naphtha.
75 gal. wash oil residue with naphthalene.

The wash oil remaining in the still is drained into cooling pan (M), where it is cooled in the air to crystallize out the naphthalene. The wash oil is drained away from the latter into tank (N), and then is returned to the main circulating tank (D). In large plants where the amount of naphthalene is great, a centrifugal dryer is employed for the purpose of separating the small amount of oil remaining in the naphthalene, and also for reclaiming the naphthalene from the separating

sump at the foot of the gas cooler. The crude naphthalene so obtained can be sold as such, or may be put into the tar in the coke plant.

The products obtained from the crude still will satisfy many commercial purposes in normal times. Moreover, at present the demands of chemical manufacturers for benzol and toluol of a high degree of purity have made it advisable to accomplish the complete process of purification at the coke plant to serve this important part of the trade. For this purification the crude benzols are first washed with sulphuric acid and then with caustic soda and water. This operation is accomplished in agitator (O), which is a large lead-lined vessel with an efficient mechanical mixing device for bringing the acid and benzol into intimate contact. The acid is commercial concentrated sulphuric acid (66 deg. Bé). The quantity used is accurately measured from the meter tank (p). The caustic soda solution is prepared in the tank (Q) and measured in the meter tank (p₁).

The acid has the effect of reacting with and to a large extent polymerizing most of the impurities which consist of various olefines and substances of similar character, together with certain phenoloid bodies. This results in the formation of resinous substances of very high boiling point, part of which are insoluble in the benzols and settle out with the acid in the bottom of the agitator, while part go into solution, giving the benzol a dark brown or a reddish color. The acid sludge is drawn off and treated, as will be described later. The caustic soda neutralizes any traces of acid which may remain in the agitator and effect the removal of some of the phenoloid bodies. After the soda wash the benzol is a lighter brown color, but always requires distillation. The washed benzol is delivered from the agitator to the still (R). This still is generally of the same capacity as the crude still, but is provided with a very efficient dephlegmator. Sometimes purified products of less exact boiling points are desired. In this case the washed benzols are distilled rapidly, simply to separate the benzol from the resinous materials in solution. The products so produced are termed "purified," e.g. 90 per cent purified benzol, 50 per cent pure benzol,

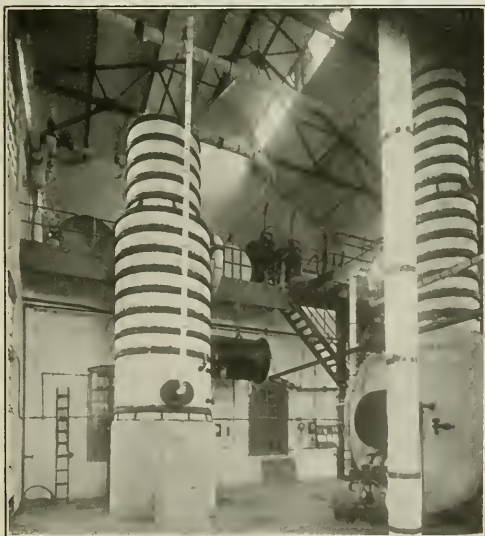


FIG. 3—BENZOL RECOVERY PLANT—WASH OIL STILL AND CRUDE STILL

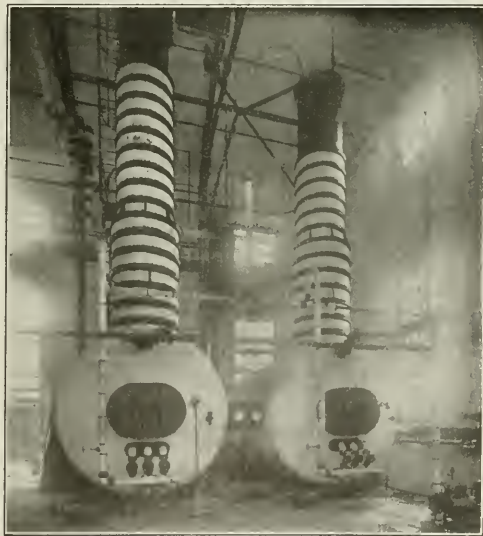


FIG. 4—BENZOL RECOVERY PLANT—CRUDE AND PURE STILL

etc., the nomenclature being based on the percentage in test distilling under 100 deg. C. The distillation for the preparation of pure products is conducted more slowly, the condensate being collected in receivers (S), and tested carefully before placing in the final storage tanks.

Great improvement has been made in recent practice in the distillation of pure benzol and toluol. In a well-designed plant the cuts are remarkably clean and the percentage of intermediate fractions small. At one benzol plant pure benzene is regularly being produced of a grade such that less than 5 per cent. distils below 80.1 deg. C. and 95 per cent distils within 0.3 deg. C. Pure toluene also is being made of which less than 5 per cent distils below 110.0 deg. C. and 95 per cent within 0.5 deg. C. This extraordinary degree of purity is of great advantage to manufacturers of explosives and synthetic chemicals requiring the use of pure benzols. The ease with which these distillations can be effected and the sharpness of the cuts obtained is very remarkable. Much of the secret of success lies in the correct design of the dephlegmator. The record of one plant shows the following average figures for the distillation of crude benzol containing toluene:

Pure benzene	85.3%
Intermediates	3.4%
Pure toluene	9.8%
Residue	1.3%
Loss	0.2%

The residue is often allowed to go to waste; but may be mixed with the coke-oven tar without injury.

The water and caustic soda used in the agitator are drained to the sewer. The acid sludge drained from the agitator is delivered to a boiler (T), in which it is treated with direct steam. This effects a separation of the resinous materials in the form of a heavy carbonaceous spongy deposit. An acid of about 40 deg. Bé is recovered and may be used on the coke plant for making ammonium sulphate. The boiler is covered during the operation of steaming and the escaping vapors are condensed in a cooler.

Regarding other details, such as the arrangement of pumps, storage tanks and piping, the diagram is self-explanatory.

The upkeep of a benzol plant costs remarkably little and the labor required in operation is small. A complete plant handling 5000 gal. of light oil per 24 hr. is operated by five men on day turn and three men on night turn, with two chemists for control testing and three laborers on day turn only for loading shipments and for general utility purposes.

The apparatus that is subjected to the most severe conditions is the superheaters. Spare superheaters should always be provided and the apparatus arranged so as to be readily interchanged. All apparatus for heating and cooling the wash oil should be so arranged that each individual unit can be taken out easily without disturbing the other apparatus. All apparatus with the exception of that exposed to sulphuric acid is made of iron and steel, no special alloys being required. It is very essential that the utmost precaution be taken in the arrangement of the piping to obviate the possibility of accidental mixing of the different products.

Since benzol is a by-product of coke and gas making, those items in the cost of its production which are involved also in coke and gas production, are not chargeable to the benzol. In other words, the cost of making coke-oven benzol includes only the cost of its extraction from the coke-oven gas, and that of its purification. This cost in the United States will vary according to local conditions, but usually lies between 4.0 and 7.0 cents per gallon.

At the close of the European war, when prices again become normal, it will be possible with the large plant capacity then available to make a substantial profit from the production and sale of automobile benzol (90 per cent-purified) at prices competing with those of gasoline. There are other large uses creating a demand for the various benzols, described in earlier paragraphs and further uses will be developed as the supply of the material becomes greater.

The effect of the removal of benzol on the calorific value of the gas has been well worked out by J. W. Shaeffer, who recently published his results in an article read before the October, 1916, meeting of the American Gas Institute. The actual loss in the calorific value of the gas amounts to about 5.8 per cent, which is a figure representing the average practice of about thirty by-product coke plants. The figure agrees well with theoretical considerations. The result is that more debenzolized gas has to be used for accomplishing a given heating effect. Assuming that one ton of coal makes 11,000 cu. ft. of gas, a reduction of 5.8 per cent is equivalent to 638 cu. ft. less gas. As boiler fuel this gas is worth about 6 cents per 1000 cu. ft., so that the reduction may be figured to cost about 3.83 cents per ton of coal, i.e. about 8 per cent of the normal value (based on gasoline prices) of the total benzol recovered.

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Chemical and Electrical Porcelain

Joint Meeting of American Electrochemical Society,
American Chemical Society, and Society of
Chemical Industry

Authorities on the subject of ceramics will talk on the manufacture of "chemical and electrical porcelain" in the United States at a joint meeting of the American Electrochemical Society, American Chemical Society and Society of Chemical Industry to be held at the Chemists' Club, on Friday evening, February 9. The speakers will be L. E. Barringer, of the General Electric Company, president of the American Ceramic Society; A. V. Bleining, of the Bureau of Standards, Pittsburgh; and Charles F. Binns, director of the New York State School of Clay Working and Ceramics, Alfred, N. Y.

The development of the manufacture of porcelain in the United States since the war has been very rapid. Before the war all of the better grades of porcelain and ceramics were imported, but this country is now making products which compare very favorably with those products formerly imported. In the manufacture of electrical porcelain this country excels all other countries. Samples of some recent products will be shown.

Detroit and Pittsburgh Meetings of American Electrochemical Society

The spring meeting of the American Electrochemical Society will be held at Detroit, Mich., from Wednesday, May 2, to Saturday, May 5, inclusive. On May 2, visits to automobile plants will be made, with a "get-together" roadhouse dinner in the evening. On May 3, sessions will be held for Electric Steel, Ferroalloys, and general papers, with a smoker in the evening. On May 4, there will be sessions on Non-Ferrous Metals, and Low-Temperature Electrochemical Processes, followed by visits to electric steel plants and power houses in the afternoon, and addresses by President Fitzgerald and Mr. Alexander Dow in the evening. The session of May 5 will be devoted to electrodeposition of metals, theory and prevention of rusting of iron.

The fall meeting will be held in Pittsburgh, from Wednesday, October 3, to Saturday, October 6, inclusive.

Presentation of the Perkin Medal to Ernst Twitchell

On Friday evening, Jan. 19, in Rumford Hall, Chemists' Club, before a splendid gathering and amid suitable patriotic decorations, the Perkin Medal for this year was formally presented to Dr. Ernst Twitchell for his work on the hydrolysis of fats, in a meeting of the New York Section of the Society of Chemical Industry, held jointly with the Sections of the American Chemical Society and the American Electrochemical Society.

Dr. JEROME ALEXANDER, chairman of the New York Section of the Society of Chemical Industry, presided. He first made the announcement that Dr. Parker C. McIlhiney, secretary of the New York Section for many years, had resigned and that Dr. Allen H. Rogers had been appointed to fill his place. A rising vote of thanks was tendered to Dr. McIlhiney for his long and efficient service as secretary of the New York Section.

In coming to the subject of the evening, Dr. Alexander gave a brief review of past Perkin medal awards and of notable discoveries in general in America. He said America has contributed more than her share of the notable discoveries of the world and not a few of these have been in the field of chemistry. In introducing DR. CHAS. F. CHANDLER, the presentation speaker, as the "dean of the chemical profession in America," he took occasion to congratulate him on the celebration of his eightieth birthday.

Dr. Chandler then delivered his presentation address, which is printed in full below, reviewing briefly the state of the art prior to Dr. Twitchell's work and giving a résumé of his work. He then presented to Dr. Twitchell the medal, with a few felicitous remarks "as a token of the esteem and affection of his fellow chemists."

Dr. TWITCHELL accepted the medal with a few words of thanks for the appreciation of his work, and followed with a history of his discoveries in the hydrolysis of fats. He was followed by Dr. A. C. LANGMUIR of Marx & Rawolle, Brooklyn, N. Y., who told about the Twitchell process in the glycerin trade, by Dr. MARTIN H. ITTNER of Colgate & Co., Jersey City, N. J., who spoke on the Twitchell process in the soap and candle industry, and by Mr. HERMAN B. SCHMIDT, who concluded the program with some interesting personal reminiscences.

The evening was very enjoyable. The speeches were brief and to the point. Their full text follows:

Presentation Address

By C. F. Chandler

It is my privilege and very pleasant duty as Senior Past President of the Society of Chemical Industry, residing in this country, to present to Ernst Twitchell, B.S. and D.Sc., the eleventh impression of the Perkin Medal, in recognition of his most original and valuable work in Applied Chemistry.

Dr. Twitchell was born in Cincinnati, on February 26, 1863. He graduated in 1886 from the University of Cincinnati with the degree of B.S., and in 1915 received from his alma mater the honorary degree of Doctor of Science. On his graduation in 1886, he was appointed chemist to the Emery Candle Company of Cincinnati,

and has been connected with that firm ever since. At present he is chemical director to the Emery Candle Company, president of the American Oil Treating & Hardening Company, and chairman of the Board of Directors of the Twitchell Process Company.

Dr. Twitchell has devoted the past thirty years chiefly to the chemistry of fats. His investigations and discoveries have been given to the chemical world in the form of articles in various chemical journals and in letters patent of the United States and other countries.

In 1891 he published his method for the determination of rosin in the fatty acids of soap. The method is based on the fact, observed by him, that the fatty acids when dissolved in absolute alcohol, are readily and completely converted into ethyl ethers, by the action of dry hydrochloric acid gas which, absorbing the water

set free, acts to induce the reaction. On the other hand the rosin acids under the same treatment remain unchanged, and may be determined volumetrically with standard soda solution, or gravimetrically. Lewkowitsch, in his comprehensive work on "Oils, Fats and Waxes," remarks: "Of all the methods for determining rosin acids in the presence of fatty acids, the Twitchell method gives the best results."

Dr. Twitchell's most important contribution to industrial chemistry involves new and improved methods for the hydrolysis of oils and fats for the production of the free fatty acids and glycerin. These methods have very largely superseded the old methods such as that of Chevreul & Gay Lussac (in 1825), who saponi-

fied in open kettles with alkali. This process was improved by Milly in 1881, who substituted milk of lime for alkali, and later by conducting the saponification in closed vessels, under pressure, reduced the amount of lime required from 14 per cent of the fat to as low as 2 per cent. Then came the process of Dubrunfant first applied practically in 1842 by Jones and Wilson, in which the fat was saponified by sulphuric acid, and the fatty acids subjected to distillation.

Wilson and Gwynne later applied the discoveries of Bertholet and Melsens in a process in which the fat was decomposed by superheated steam and subsequent distillation, which was practiced at the works of Prices Candle Company, Battersea. Finally in 1854, Tilghmann introduced his process in which the fat, emulsified in water, was forced through a coil at a temperature of 320 deg. C. Marix found that by adding a little calcium or magnesium carbonate to the water, the temperature and pressure could be very materially reduced to as low even as 3 to 5 atmospheres.

The art of saponifying the fats had reached this stage of development when Dr. Twitchell made an entirely new departure by the application of new reagents, which by acting as catalysts, even when used in such small proportions as 1 to 2 per cent, are able to completely saponify the fats. The operation may be conducted by simply boiling the fat with water and the proper quantity of the "saponifier." The agents first employed by Dr. Twitchell were the sulfo-acids of the fatty acids, such as sulfo-stearic acid, sulfo-oleic acid, etc. Later



ERNST TWITCHELL

Dr. Twitchell found that by introducing an aromatic radical into the sulfo-acid, a much more satisfactory catalyzer was obtained; a sulfo-fatty aromatic acid. Such aromatic radicals as are furnished by benzene, phenol, and naphthalene are employed; naphthalene stearosulfonic acid being a favorite catalyzer.

These acids when converted into salts of such metals as barium, calcium, magnesium, aluminium, etc., can be produced as stable dry powders, to be used with a suitable proportion of sulphuric acid, or hydrochloric acid to make them active.

The Twitchell process has made possible the large scale saponification of fats for the production of crude glycerin free from salt and of fatty acids for direct combination with soda as to make soap instead of using the more expensive caustic lye on the neutral fat.

Low-grade fats, such as garbage grease, cottonseed oil foots, etc., were formerly with difficulty used in the soap or candle industry. Such materials can now be readily worked up by the Twitchell process, the fatty acids being distilled to remove color before use. This releases a large quantity of the higher grade fats for use as food products.

The bulk of the soap used in Belgium, Holland, Germany and Scandinavia is said to be prepared from fatty acids direct, and 75 per cent of these acids are made by the Twitchell method. Millions of pounds of fat are saponified yearly in the United States by this process, and practically all of the larger soap factories have Twitchell plants.

All of the recent books in German and English on the soap and fat industries discuss the Twitchell process in full.

Address of Acceptance of Perkin Medal

By Ernst Twitchell

The first suggestion which lead to my discovery of a special catalyzer for hydrolysing fats came to me in studying the so-called "acidification process." This was one of the oldest methods used in candle factories for separating glycerol from fatty acids. It consisted in treating the fat at a fairly high temperature, over 100 deg. C., with a small amount of concentrated sulphuric acid, 4 per cent or considerably less could be used; the product was then boiled with an excess of water. The result is a layer of fatty acids floating on the acid water containing the glycerol.

This reaction could not be explained by the assumption that there is a combination of sulphuric acid with the fat or fatty acid and glycerol, which decomposes during the subsequent operation of boiling with water, because there was not enough sulphuric acid to combine with all of the fat. Various theories have been given to explain the acidification process, some quite absurd. For instance, in one text-book it is stated that fats consist of minute globules surrounded by membranes and that the function of the sulphuric acid is simply to char and destroy these membranes, leaving the fat in a condition to be hydrolysed by water at 160 deg. Another theory was frequently seen even in recent articles; it stated that compounds are formed which cause the fat to emulsify with water, and the idea evidently is that if a good enough emulsion is obtained, hydrolysis will take place even at 100 deg. I have seen this theory given to account for the action of my hydrolysing reagent. As a matter of fact, fats do not hydrolyse at 100 deg., practically speaking, with water alone, even though they may be perfectly emulsified. At higher temperatures than 100 deg., and under pressure, hydrolysis takes place, as is illustrated in the autoclave process of separating glycerine.

In the course of practical experiments with the acidifi-

cation process I found that I could reduce the amount of sulphuric acid used very considerably and yet obtain complete decomposition; but often the boiling with water had to be decidedly prolonged. It seemed clear that there was some catalytic agent which caused the reaction between the fat and the water in this process of boiling, and it would naturally occur to any one that this catalyzer was probably some sulphur compound produced by the action of sulphuric acid on fat. I found that compounds of this nature could be roughly separated from the fat which contained them by treating with petroleum ether in which they were insoluble. They could be further purified by solution in ether and extraction with water and were easily identified as sulphonic acids by their acidity, the formation of potassium sulphate on fusion with caustic potash, and other characteristics.

It occurred to me to prepare this catalyzer outside of the body of the fat, thus avoiding the action of the sulphuric acid in forming with the fat undesirable compounds, in charring, discoloring, and partially destroying it.

As these sulphonic acids were probably produced by the action of the sulphuric acid on the oleic acid constituent of the fat, I first studied the results of the action of sulphuric acid on pure oleic acid under various conditions of temperature, quantity, etc.

The action of sulphuric acid on oleic acid at low temperatures, as was known, produces a compound of sulphuric acid, stearo-sulphuric acid, an acid sulphuric ester. This was not the catalyst that I was seeking. It very probably has all the properties of a catalyst for the hydrolysis of fats except one; it is decomposed on boiling with water, and as the hydrolysis of a fat hardly takes place at all under any circumstances at a temperature lower than 100 deg., it is plain that this compound would not serve my purpose.

The compounds obtained on treating oleic acid with sulphuric acid at a temperature of 100 deg. or over are not sulphuric acid compounds, but are true sulphonic acids. The principal one seemed to be derived from two molecules of oleic acid and contained one sulphonic acid group and one carboxyl group.

I have never seen this sulphonic acid described, but believe that I had in my hands a fairly pure compound of the composition $C_{54}H_{98}(SO_3H)COO$. $C_{54}H_{98}COOH$. This was my first hydrolysing reagent or saponifier. But as it was difficult to prepare commercially in fair yield and of any degree of purity, I dropped further investigation along this line on the accidental discovery of the fatty aromatic sulphonic acids, described in the *Journal of the American Chemical Society* of January, 1900.

In this research the most important question was: "What properties must a substance have to act as a catalyzer to accelerate the hydrolysis of fats?" My views on this subject I have partially expressed in my paper, "A Reagent in the Chemistry of Fats," published in the *Journal of the American Chemical Society* of February, 1906, where I say that it must be a strong acid, one dissociated strongly in water giving a considerable concentration of hydrogen ions; and then it must be soluble in both fat and water and cause the one to dissolve in the other.

The only bodies that I can at present conceive to have the desired properties are sulphonic acids containing higher fatty radicals. They have the physical character of fats or oils, yet are soluble in water forming soapy solutions, and are strong acids.

As I have said, the discovery of the fatty aromatic sulphonic acids was made by accident. I had a mixture of oleic acid and benzene, which I treated with an excess of sulphuric acid and then poured the mass

into water. I was not surprised to find an oily layer floating on the acid water, and when I found this oil to be soluble in pure water, that also did not surprise me, as I supposed I had simply stearo-sulphuric acid; but when I found that, after boiling, it still remained soluble, I felt sure that I had a sulphonic acid, and the analysis of the product confirmed my conclusion. This is the compound which has been put to practical use in the separation of glycerol and fatty acids. Instead of benzene, naphthalene is used with oleic acid in the manufacture of the commercial article. This "saponifier," when added in the proportion of half a per cent or less to fat boiling with water in an open tank, will cause the separation of the glycerol.

Besides the compound containing two stearic radicals and a sulphonic group, the first which I found to have the catalytic property, and the fatty aromatic sulphonic acids, I have also prepared hydrolysing reagents by treating oleic acid at 200 deg. to 220 deg. C. with sulphur, or in the cold with sulphur chloride (S_2Cl_2), and when oxidizing with nitric acid, potassium permanganate, bromine, or other oxidizing agent. The resulting compound contained one sulphonic and one carboxyl group and its molecular weight and other properties showed it to be a sulphonic acid of the stearic radical.

Belonging to this class of substances is a compound, cetyl sulphonic acid, described by A. Reyhler two or three years ago. When I saw this description I was sure that it was also a catalyst of the same type as my reagent, although Reyhler does not mention this as one of its properties.

As this is a typical compound, it may be interesting to describe how it was prepared, partly following directions given in Reyhler's paper. Cetyl alcohol, prepared by saponifying spermaceti with caustic potash and extracting the soap with petroleum ether, was converted into the iodide by dropping iodine into a heated mixture of the alcohol and red phosphorus. This iodide, after purification, was converted into the sulphhydrate by treating with alcoholic KHS and the cetyl sulphhydrate converted into cetyl sulphonic acid by oxidizing with potassium permanganate, the excess of which was reduced with sodium sulphite. The cetyl sulphonates could be freed from most of the foreign matter by taking up with hot water from which sodium cetyl sulphonate crystallized on cooling. This was dried, extracted with petroleum ether, then dissolved in water and treated with hydrochloric acid. The salted out cetyl sulphonic acid was dissolved in ether and remained in a nearly pure state as a residue on evaporating the ether. It can be further purified by crystallizing its sodium salt from dilute alcohol and there can be no doubt of its composition. It is a simple sulphonic acid of a hydrocarbon of the paraffine series.

Reyhler explains some peculiar properties of this compound in this way: The sulphonic radical tends to make it very soluble in water, while the long hydrocarbon chain has just the reverse effect. The result is that it forms colloidal solutions. Fahrion, in reviewing Reyhler's article, calls the cetyl sulphonic acid, "Reyhler's hydrogen soap," and that term, *hydrogen soap*, is as good a definition as I can think of to cover the whole group of compounds which catalytically induce hydrolysis of fats on the principle of my discovery. An alkaline soap plus hydrogen ions would no doubt have the same effect if it were possible to have such a combination. Besides its use in hydrolysing fats, my catalytic agent has been applied to other less important ones. A catalyst which would accelerate the hydrolysis of an ester in the presence of an excess of water would also accelerate the esterification of a fatty acid and an alcohol on the removal of the water

formed. Fatty acids can be made to combine with glycerol and other alcohols of high boiling point by simply treating a mixture of the two with a small quantity of the reagent and evaporating the water formed at 100 deg. C.

The solubility of sulpho-fatty acids in both fat and water leads to a method of separating solid and liquid fatty acids of which I have made some application. If a small quantity of the sulphonic reagent is dissolved in melted mixed fatty acids and the mixture allowed to cool, the solid acids will crystallize out pure and the liquid acids will contain the sulpho-fatty acids, being thus rendered slightly soluble in water, and on treating with water can be washed out from the mixture, partly in solution but mainly as an emulsion.

Patents have recently been obtained by Grigor Petroff of Russia on a reagent obtained as a by-product in refining petroleum with fuming sulphuric acid. This is a sulphonic acid of hydrocarbon radicals, probably both of the paraffine series. It is a very efficient catalyst in the hydrolysis of fats, for which purpose it is now largely used.

The Twitchell Process and the Glycerine Trade

By A. C. Langmuir

Some years ago a manufacturer asked my assistance in developing a chemical process. He wanted a process which would "cost nothing to work, would take nothing out of the product and would put nothing in." This man had heard nothing of catalytic methods, but his conception of the ideal chemical process which he was requiring corresponded closely to the modern catalytic methods such as the platinum contact process for the manufacture of sulphuric acid, which costs nothing to operate, once the contact mass is prepared, and which brings about the combination of sulphur dioxide and oxygen without adding an impurity which must be subsequently taken out or removing something which would lower the yield.

The Twitchell catalytic process goes far toward meeting this idea in the saponification or breaking up of fats and oil into their constituents, glycerine and fatty acids. Twitchell's invention (Patent 601,603, July 17, 1897) was made at a time when catalysis was not the universal subject of attention it is to-day. The Badische process for the catalytic production of sulphuric acid had not been published, and catalysis was a new thing in chemical industry.

Twitchell's work has been characterized by a sound appreciation of the work of physical and organic chemists and his analytical and technical methods have been worked out, not empirically, but from theoretical premises. Thus the Twitchell method for the determination of rosin in mixtures with fatty acids, as in soap analysis, rests upon the principle of the esterification of the fatty acids when treated with hydrochloric acid gas in presence of absolute alcohol and his discovery that resin acids when so treated refused to combine with the alcohol and could subsequently be separated as pure rosin. Although published in 1891, this method stands to-day as the most accurate process for the determination of rosin in presence of fatty acids.

Again in 1897 we find him bringing out a method for the separation of saturated and unsaturated fatty acids based upon the solubility of fatty acids with double bonds, such as oleic acid, in concentrated sulphuric acid at ordinary temperatures with the formation of sulfo-fatty acids soluble in water. The saturated fatty acids such as stearic acid are unacted on. In 1914 Twitchell makes use of the principle of the equal depression of the freezing point for equal molecular proportions and determines the composition of mixtures of fatty acids

by the observation of the freezing point in the Beckmann apparatus. To test whether a given sample of fatty acid is identical with a fatty acid of known character he adopts the novel plan of adding a portion of the known acid and noting whether there is any change in the melting point of the mixture.

Possibly his investigation of the action of concentrated sulphuric acid on fatty acids led to his discovery of the catalytic action of these sulfo-fatty acids in bringing about the decomposition of fats by water, as little as 0.5 per cent splitting up the fats almost completely on digestion with water.

The prevailing method for the manufacture of soap consists in the saponification of the fat by boiling with caustic soda lye. The fatty acids combine with the soda as soap, which is separated by the addition of salt and comes to the surface in the molten condition. The glycerine is set free and remains dissolved in the spent lye. It is contaminated by the presence of salt used to render the soap insoluble. During the concentration of the spent lye for the recovery of the glycerine a large quantity of salt is thrown out, making the evaporation somewhat difficult, although this difficulty has been largely eliminated of late years by the use of properly designed evaporators working in vacuo. The final crude glycerine is a saturated solution of sodium chloride and some sulphate together with sodium salts of the lower fatty acids, in glycerine and water. The glycerine averages about 80 per cent and contains about 10 per cent mineral salts.

The glycerine refiner distills this crude soap lye glycerine with superheated steam in vacuo for the production of dynamite glycerine and chemically pure. The presence of so large a quantity of salt raises the boiling point of the glycerine and reduces its vapor tension so that the output is reduced. Furthermore, the salt accumulates in the still, producing finally a semi-solid mass of salt and glycerine, together with tarry matter which constitutes the "foots" of the glycerine trade. It is a difficult matter to extract all the glycerine from this residue without undue loss. The treatment of the "foots" is one of the problems of the glycerine trade.

The glycerine distiller, therefore, prefers a crude glycerine which is free from this large admixture of salt. Up to the early nineties all the crude glycerine refined consisted of what is termed saponification or candle crude. It was the by-product of the candle factory and was produced by the breaking up of fat in autoclaves by heating under pressures of 200 lb. and more with water and a little lime. The fat was split into fatty acids and glycerine directly and the latter was a product of considerable purity, containing about 88 per cent glycerine and less than 1.0 per cent of mineral matter. With the greatly increased demand for glycerine for explosives the soap makers, who formerly discarded their spent lyes, found it profitable to work them up, and to-day scarcely a soap plant can be found that does not recover its glycerine as a by-product. This change in the business compelled refiners to develop methods for distilling soap lye crude glycerine and eventually the larger refiners were working mainly on soap lye rather than candle crude, although there were still a number of glycerine refiners who worked exclusively on candle crudes. Saponification crudes free from salt have always been in greater demand and have commanded a higher price per unit of glycerine. For several years before the advent of the Twitchell process it looked as if saponification glycerine would practically disappear as a raw material in glycerine refining, but with the success of this process the Twitchell saponification crudes made their

appearance and are now a factor of very considerable importance.

The ideal of the glycerine refiner has thus been the production of a saponification rather than a soap lye crude by the soap manufacturer. It has also been the hope of the soap trade to obtain directly by the deglycerinizing of the fat a relatively pure glycerine as a byproduct and free fatty acids which could be combined with the cheap alkali, carbonate of soda, to make soap instead of the relatively expensive caustic soda. To meet this need have been developed the Twitchell process, the Krebitz lime saponification method and the Connstein ferment process.

The Twitchell process is characterized by its simplicity, and the low cost of the plant. Prior to Twitchell's discovery free fatty acids could only be obtained by the autoclave process involving a heavy capital outlay for copper apparatus which could only be used in small units and at a high temperature and pressure, making the operation expensive and somewhat dangerous. The autoclave saponification was used only in the preparation of fatty acids for candle manufacture, as the process was too costly to be used in the production of fatty acids to be used in soap. The Twitchell process is effected in loosely closed wooden tanks by digestion with water and as little as 0.5 per cent of the reagent and at a temperature not exceeding that of exhaust steam. The reaction may be carried out on a scale limited only by the size of the tank. The Twitchell process has made possible the saponification of fats on a huge scale for the direct production of free fatty acids and saponification glycerine. When combined with the distillation of the fatty acids for the improvement of their purity and color it has opened up for the soap trade the use of low-grade fats such as garbage grease and cotton seed oil foots, the distilled fatty acids being combined directly with carbonate of soda to produce light-colored soaps, and the glycerine being made available for the manufacture of dynamite glycerine. In this way the Twitchell process has benefited the glycerine trade in these days of glycerine scarcity by opening up new sources of supply, which were previously unavailable.

In Germany, Austria, Belgium, Holland and Scandinavia the larger soap plants prepare soap from fatty acids directly, and it is stated that in most of them the Twitchell process is used for the saponification of the fats.

The crude glycerine prepared by the Twitchell process comes to us from all parts of the world in normal times. There is no evidence that it is any less pure than the saponification glycerines prepared by other processes provided the fat used as a raw material is reasonably pure. Of course, a crude glycerine manufactured from a low-grade fat will fall behind a crude made from good tallow, but this is the fault of the fat and not the Twitchell process.

The Twitchell Process in the Soap and Candle Industry

By Martin Hill Ittner

It is essential in the candle industry to have a satisfactory method for separating the fatty acids, as such, from fats and oils. In the soap industry such a method, although it may be considered highly desirable, is not absolutely essential, since very satisfactory methods of direct saponification by alkali with the formation of soaps have long been utilized.

In recent years there has been an ever increasing demand for fats and oils and for glycerine, resulting in greatly increased market prices for these articles. The

market for soap and candle materials is directly related to the market for fats and oils for edible purposes, and an increased demand from either source usually results in higher prices for all fatty materials. High costs of fatty materials have made the practice of economy in the soap business essential. This economy may manifest itself in several ways. We will assume at the outset that the soap manufacturer wishes to maintain the quality of his products and therefore does not wish to make any sacrifice in this direction. His economy must therefore direct itself in one of the following directions: He must be able to utilize the fats and oils which give the greatest soap-making value at the lowest cost per unit, whether these materials are of the better or of the poorer grades, and he must so utilize his raw material that his final product will be of the same high quality no matter which grade is used. This means that he must have a method for getting good results out of poor material when poor material gives him the greatest value. It is also essential that he have some method whereby he may realize the maximum yield of glycerine at a low expense for recovery. This will readily be understood when I explain that at present market prices for fats and glycerine, which are both abnormally high, the value of the glycerine which can be obtained from one pound of neutral fat is about one-third of the cost of the fat. Another possible way of economizing is by quicker and easier methods of manufacture.

All of these advantages have been realized in some degree by the advent of the Twitchell process. This process has given a quick and easy method of obtaining fatty acids and glycerine from the better grades of fats so that the fatty acids are at once ready for making into better grades of soap, and the glycerine is in a condition suitable for easy refining. With care of operation the yield of glycerine may be made to approximate closely to that theoretically obtainable. When one operates on fats of poorer quality, and this may include black greases, the Twitchell process furnishes a most satisfactory method for saponifying. It renders the glycerine available even from such material and gives acids in good condition for refining by means of distillation. Such acids when carefully distilled yield a product of light color suitable for making good soaps of light color.

The use of fatty acids, as such, has made it practicable to use soda ash very largely in the place of caustic soda. The former will combine direct with fatty acids making soap from which the glycerine has already been recovered, whereas caustic soda is necessary for the direct saponification of fats into soap, and tedious methods must be used for recovering the glycerine, and, except with the greatest care, the yields will be poor. It will be thus seen that in the use of fatty acids a saving may be effected even in the alkali employed, as soda ash is considerably cheaper than caustic soda per unit of alkali.

Fatty acids suitable for making into soaps are also suitable for making into candle material. Partial solidification on cooling, will, with the aid of pressing, separate the solid from the liquid acids. The former yields commercial stearic acid so extensively used in candle manufacture and the liquid portion yields the oleic acid, or red oil of commerce. Red oil is used for many purposes, one of the most important being in the manufacture of soaps for washing wool. The manufacture of stearic acid and red oil did not originate with the Twitchell process, but the advent of the Twitchell process gave a new and satisfactory method for the saponification of fatty materials at atmospheric pressure with advantages over methods formerly used. Saponification by means of the Twitchell process may be carried out on a larger scale, with less danger and

with greater ease than is obtainable by other methods of acid saponification.

Twitchell's first process in which he recommended the use of sulpho-oleic acid was soon very much improved by the use of naphthalene along with the oleic acid during sulphonation. Whatever the chemical action in the formation of this reagent, it is my observation based on many experiments that satisfactory saponification will result from saponifier made as Twitchell recommends, whereas poor results only are obtainable when separate sulphonation and subsequent mixing are tried. I may say that I was among the first to have an opportunity to become acquainted with the process, and that this acquaintance has become closer with added years.

This process has been put to extensive use not only in America but also in European countries.

Twitchell later devoted himself to a method of manufacturing his reagent which would enable him to produce it in a more concentrated form. He accomplished this by methods of washing, extraction, precipitating as an insoluble salt readily convertible into an active reagent, and drying.

Twitchell and others allied with him have been busy in trying to still further perfect the process of atmospheric saponification of fats into fatty acids and glycerine with the result that a new sulphonated reagent with increased efficiency has lately been put upon the market.

The Twitchell process has been so simple in use that one is almost inclined to look upon it as nothing out of the ordinary. On careful thought one is forced to conclude that it is this simplicity which has become almost commonplace that commends it most to the many who have become familiar with it in operation.

An Appreciation

By Herman B. Schmidt

President Twitchell Process Co.

Thirty years is a span of life; practically a generation has passed. In these thirty years there have been in this country profound changes, unparalleled growth, and vast development. The bankers may tell you that the bank deposits have increased maybe ten times in this span of life. The iron people tell us the production of iron has increased about ten times. But what measure of increase can be put upon the developments that increased the chemists' opportunity—how many times? Surely a hundredfold at least.

Only a generation ago, when the industrial chemist started on a career, what had he before him? Simply the obligation to create an opportunity. As an example, going back to conditions then in Chicago, it was hard work to gather together a dozen men at a gathering. There were a couple of iron and steel chemists, two railroad chemists, a couple of metallurgical chemists, one soap chemist, one packing-house chemist, and a couple of assayers and a couple of professors.

The audience will get an idea of how inadequate the conception was of what a chemist's work consisted in. One day, in walking across the stock yards in Chicago, I was stopped by one of the then partners of what to-day is one of the largest institutions of its kind in this country, who said: "What do you do over at Fairbanks?" Explaining what the routine duties consisted of, what new things had been taken up by the laboratory, he finally said he did not think his institution could employ a man full time at that kind of work; and yet, three months after that interview, that institution employed its first chemist. I

dare say that that institution to-day has at least fifty in its employ.

In Cincinnati the conditions were similar, and if we look back on the chemist's equipment and temporary abode on a far-off lot, or prairie, with no gas, no electric lights, coal-oil lamps, and gasoline torches to work with, good work was carried on under severe conditions. I am always amused when I think of the difficulties of nitrogen determination at that time compared with the Kjeldahl method of to-day. Then we required a glass combustion tube and charcoal furnace and a boy to fan the coals. If he fanned too hard, the glass tube cracked; if he did not fan hard enough, the distillate was colored and you could not titrate it.

Under just such conditions our distinguished guest started.

In comparing these meagre facilities with the magnificent equipments that every college laboratory has to-day, I am reminded of Dr. Wolcott Gibbs who said when one day in his research laboratory the inadequacy of the equipment came up: "Why, do you know how the great Berzelius got his results? Why, all he had were some bottles, a sink and a cookstove. The present generation hardly realizes the huge advantages it enjoys."

Away out in a field, in a lean-to to a still building, Dr. Twitchell, too, had to create his opportunities, and there seeds of progress were sown. There were no fixed lines to work on; every step was capable of researches and these had to be made in order to find the ways in which the chemist could make himself valuable, and gradually the structure grew. Twenty-four years ago next July there was a meeting of the Society of Chemical Industry at Liverpool. One morning, while riding on the second story of a tram car (the two-story horse-car affair that was a characteristic of English streets) reading the itinerary of the meeting, a party slapped me on the back and said, "Are you a chemist?" "Yes." "Oh!" he said, "you are from the States. Where from?" "Chicago, but expect to go back to Cincinnati to live." "Well," he said, "Cincinnati; why, do you know Mr. Twitchell?" "Yes, we went to school together." "Well," he said, "he has made the best contribution to the chemistry of soaps that I know of. His method of determining the percentage of rosin in a soap is the only method that gives us the means of determining what a competitor has in his soap," and then my party said: "Here is my card, I am Dr. Lewkowitsch, and I had the experience of Mr. Twitchell's method in a soap works at Warrington." So our honored guest early in his career had made a valuable contribution to chemistry and was known to every chemist that was in fat and soap lines.

Only a few more years elapsed when Mr. Twitchell was able to announce the working out of the Twitchell process of glycerine recovery. The means employed were so novel that when the German Patent Office was asked to pass upon the patentability of the Twitchell reagent, they doubted that a compound described by Mr. Twitchell could exist. It is needless for me to dwell on what the process has done. You have heard that told to-night.

Just one more word. The young chemists will appreciate much more what Mr. Twitchell has done. His methods, employed in hundreds of factories throughout the world, have necessitated chemical control of operations and so have afforded just that many more opportunities for the employment of skilled chemists in those works. So what one man has done benefits one hundred or one thousand men through a new opportunity, and this is only one example of where the opportunity has grown a hundredfold.

Metallurgy of Cadmium—Raw Materials, Technique and Economics

By Franz Juretzka

Translated from "Metall und Erz" (12:235, 1915)

By Oliver C. Ralston

TECHNIQUE

As the result of the increasing use of metallic cadmium, the possibility of increasing the supply is of importance. In America especially of late the increasing production of cadmium is noticed. It was thought that the following notes would not be without interest to smeltermen and metallurgists.

Some of the common properties of cadmium, as compared with those of zinc, are as follows:

	Cd.	Zn.
Specific gravity	8.6-8.7	7.0-7.1
Melting point	325 deg. C.	420 deg. C.
Boiling point	750 deg. C.	900-1,000 deg. C.

The temperature of condensation is between 415 deg. and 520 deg. C. for both metals.

The principal ores from which cadmium is recovered are zinc blende and calamine ores. In the blende the cadmium is present as the isomorphous greenockite, CdS , not only in the regular sphalerite, but also in wurtzite. In calamine it is present as CdCO_3 . Usually the cadmium compounds impart a weak lemon yellow cast to the zinc compounds or products with which they are associated. The average run of blendes contains about 0.15 per cent Cd with considerable variations (Upper-Silesian blendes 0.15 per cent, Rhenish blendes less, Sterzinger blendes about 0.2 per cent and the Przibram ore up to 1 per cent Cd). Calamines are usually richer in cadmium. For example, Wiesloch (Baden) calamines contain 2 to 5 per cent Cd and Upper-Silesian calamines 0.3-0.5 per cent Cd and over.

The greater portion of this cadmium in the ore is lost during roasting and calcining and is found in an enriched form in the flue dust, but the latter product is rarely worked up for cadmium. Flue dust from blende roasting often contains 2.6 per cent Cd, usually in the form of the soluble sulphate. After leaching with water it is comparatively easy to precipitate it as CdS by the use of hydrogen sulphide. This CdS as a rule is contaminated with arsenic and can be freed from it by a slight roast. This leaves a brown cadmium oxide, CdO , as a starting point for the preparation of various cadmium salts.

The lithopone factories often have cadmium chloride in their raw ZnCl_2 liquors. It is precipitated by the use of zinc dust or by electrolytic means. (Dr. Alberti, Langelsheim, Harz.)

Most of the cadmium on the market to-day is made from the zinc dusts. Zinc dust contains 3 to 8 per cent Cd, according to the original content of the ore.

In the wet way cadmium is sometimes prepared by dissolving zinc dust in dilute hydrochloric acid, the zinc dissolving and leaving a residue of lead and cadmium. Some of the cadmium goes into solution and is reprecipitated by the addition of more zinc dust. This residue is later distilled to recover pure cadmium.

Although this method is very simple it is usually unprofitable. The zinc chloride liquor on precipitation with lime gives a zinc oxide which invariably contains some zinc oxychloride and later in distillation it is very troublesome. (As much as 10 per cent ZnCl_2 is retained by the precipitate.) It cannot be washed out and it is lost in distillation as it distills as ZnCl_2 , passing out through the prolongs, corroding the condensed zinc and making it of little value. The zinc dust is likewise rendered pyrophoric and unsuitable for commercial purposes. The costs of the zinc dust lost by reason of these

objections must be balanced up against the value of the cadmium obtained in the process.

As a starting point for the dry-process cadmium there is used the zinc dust evolved during the first one and one-half to two hours of distillation of a zinc ore. This dust often contains as much as 6-8 per cent Cd. The cadmium content of this dust is higher the sooner the prolongs are placed on the retorts after charging. It seems to be very important to be very quickly close and lute on the condensers and place the prolongs in position, after charging the retorts. It is also very essential that all of the dust should be well loosened from the walls of the prolong by pounding with a wooden stick during the process of collecting the dust, as the first dust tends to stick to the walls, due to condensed moisture.

By strict supervision it is possible to get seven to eight kilograms of dust from each prolong during the first one and one-half to two hours of distillation, and from a furnace with three tiers of retorts this means 20 kilograms of dust from each section. This zinc dust is mixed with about 50 per cent of its weight of carbon

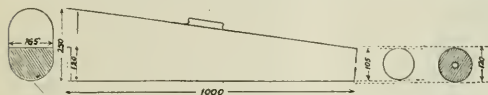


FIG. 1—SHEET-IRON CASING FOR MUFFLES; MEASUREMENTS IN MM.

and placed in a retort of the kind usually used for zinc and distilled for about 22 hours at a dull red heat. In order to insure obtaining a yield of material rich in cadmium during this operation the prolong is removed when the flame issuing from it ceases to have a brownish tinge. For a condenser there is used a conical sheet-iron prolong (see Fig. 1), in which the cadmium, cadmium oxide and some zinc oxide collect. In order to prevent the walls of the condenser from being attacked they must be coated with whitewash and a rather thick coating of cadmium oxide allowed to form.

At the close of the distillation period the condenser is removed, cooled with water and then emptied into a special container. This material will contain about 75 per cent Cd. It is of a gray white color and feels soft and greasy when molten. If it is hard and dry it is a sign that the furnace got too hot and too great an amount of zinc was distilled. Under such conditions it is possible to stratify the material in the container by strong shaking, the particles of zinc tending to collect on the top, where it can be skimmed off and returned to the retort. The residues from the retorts,

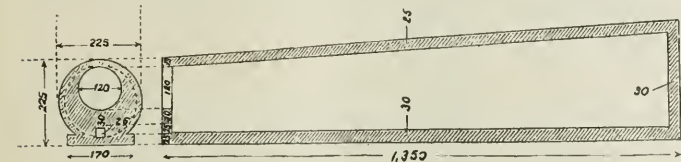


FIG. 2—CAST-IRON RETORT; MEASUREMENTS IN MM.

which contain 45-50 per cent Zn, are returned to the zinc distillation furnace.

The cadmium metal made in this manner is mixed with about 40 per cent wood charcoal, or 60 per cent

of high-grade coke, moistened, and placed in cast-iron retorts (see Fig. 2) by the use of ladles and shovels, leaving the front portion of the retort empty for the collection of molten cadmium. The condenser is immediately put on and luted on with clay. Due to the fact that the opening in the end of the condenser is so

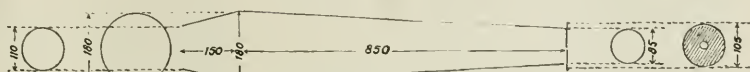


FIG. 3—CASING FOR RETORT, SHEET IRON; MEASUREMENTS IN MM.

small (only about 1 cm.), the gases first generated in the retort issue very quickly and may make necessary the repairing of the luting of the condenser. The design of the condenser is shown in Fig. 3, in which all dimensions are given in millimeters.

The molten cadmium collecting in the front of the retort is removed every four hours by the use of an iron ladle, in order to prevent its taking up too much zinc and iron. Every ten hours the condenser is removed, as a part of the cadmium boils in the retort and is caught in the condenser. During the emptying of the condenser the mouth of the retort must be closed with a brick of the proper shape. The condensed metal, which is usually shot through with little needle-shaped crystals, is dumped back into the forward part of the retort, the condenser replaced and luted on again. This also affords an opportunity to stir the contents of the retort well because the residues have a strong tendency to form crusts. Thirty minutes after the replacing of the condensers it is allowable to completely close up the exit opening in the condenser. Every morning the contents of the condenser are removed and then the retorts can be emptied.

The crude cadmium obtained in this way is removed and collected every ten days into a cast-iron kettle, where it is melted under a cover of oil and cast into



FIG. 4—CADMIUM MOULDS OF IRON WITH TWENTY-FOUR CHANNELS; MEASUREMENTS IN MM. THE CHANNELS ARE 250 MM. LONG

a mould of the type shown in Fig. 4. The sticks of metal are cut off from the "sow" by means of shears and are then ready for shipment. The dross is allowed to accumulate over a number of melts and finally is redistilled.

If the cadmium furnace is run too hot for a few days too much zinc will accompany it and even 0.5 per cent Zn is sufficient to alter seriously the properties of the cadmium. While cadmium of good quality gives sticks of good appearance, medium-grade cadmium gives sticks whose upper ends look dead. Inside these sticks are often some bubbles formed during casting, and on bending these rather stiff sticks they often break at the bubbles. The quality can also be told by the fracture of these sticks. Good

cadmium gives a brilliant crystalline fracture, while medium-grade cadmium shows a coarse-grained gleaming fracture and the poorer grades of cadmium give a fine-grained dull-gray fracture. Also a stick of good

quality cadmium will give a rustling sound much like the cry of tin when bent near the ear, while the poorer grades of cadmium will not do this.

In order to convert medium-grade into good-grade cadmium it is placed in the back of a warm retort in which a dam of sand is built, the cadmium distilling from the back end of the retort, condensing in the front end and in the condenser, and giving a high-grade metal with very little loss.

Table I.—Cadmium Production in Upper Silesia.

(By the kindness of Consul Philipp, Breslau.)

Year	Kilograms	Total Value, Marks	Sale Price	
			M/kg.	\$/lb.
1882.....	3,521	15.00	1.62	
1896.....	15,527	8.50	0.92	
1897.....	9,840	4.50	0.49	
1899.....	9,840	65,312	21.00	2.27(*)
1900.....	12,533	32,037	5.50	
1901.....	13,144	33,003	5.50	0.60
1902.....	12,825	61,500	5.50	0.60
1903.....	16,765	81,849	6.00	
1904.....	24,745	134,621	6.75	0.73
1905.....	24,568	148,068	7.00	0.75
1906.....	27,561	181,988	10.00	1.08
1907.....	32,949	255,064	11.50	1.24
1908.....	32,795	203,822	7.00	0.75(t)
1909.....	37,187	198,288	5.25	
1910.....	41,057	165,166	5.50	0.60
1911.....	42,575	224,254	6.50	0.70
1912.....	42,757	267,899	7.37	0.79
1913.....	38,575	233,812	7.62	0.82

(*) Due to heavy buying for experimental purposes at the explosives testing laboratory in Dresden.

(t) At this time the Joplin district began producing cadmium at the rate of about 7000 to 8000 kilos per year, or 15,000 to 17,500 lb. per year.

Table II.—Cadmium Production in the United States

(By the kindness of Beer, Sondheimer & Co.)

Year	Pounds	Dollars	Cost Per Lb.
1910.....	5,300	2,846	\$0.54
1911.....	27,000	16,848	0.62
1912.....	27,000	19,440	0.72
1913.....	25,000	18,850	0.75

Table III.—Cadmium Imports of the United States.

Year	Pounds	Dollars	Cost Per Lb.
1910.....	3,083	1,657	\$0.54
1911.....	5,956	3,718	0.62
1912.....	6,396	4,603	0.72
1913.....	1,999	1,508	0.75

The Grasselli Chemical Co. is said to be recovering cadmium from cadmiferous dust and from a smelter fume. The American Smelting and Refining Co. is recovering cadmium from a fume in like manner.

The uses of cadmium are rather limited. It is used in the manufacture of Woods alloys, the composition being Bi 50 per cent, Pb 26.7 or 25 per cent, Sn 13.3 or 12.5 per cent and Cd 10 or 12.5 per cent, the melting pts. being 60.5 deg. C. to 70 deg. C.

In the United States it has found considerable application in the manufacture of fusible plugs in automatic fire extinguishing apparatus. One analysis is 50 per cent Pb, 27.5 per cent Sn and 22.5 per cent Cd. Lipowitz metal is similar to Woods metal and is often used by goldsmiths in soldering jewelry.

The amalgam used for filling teeth contains 26 per cent Cd and 74 per cent Hg. Cadmium is also used in the sulphide form for oil and china painting, as iodide and bromide in photography, as the chloride in colormaking and in calico printing. The sulphide is often used in coloring silk, and the sulphate is occasionally used for affections of the eyes.

ECONOMICS

If we assume that the dust from the distillation of zinc is collected for the first one and one-half hours after charging in a zinc smelter containing 30 furnaces of 120 retorts each, and that the dust contains 5 per cent of cadmium, and further, assuming the average figure of 20 kilograms of zinc dust from each furnace during this 1.5 hour period, and 900 furnace days per month, it can be seen that the production is $20 \times 900 = 18,000$ kilograms of zinc dust per month. This is 18 metric tons or 18 long tons of dust. The dust con-

sists of 5 per cent cadmium, and assuming 35 per cent recovery it is found that by reasonable care a 35 per cent yield is possible.

Forty to 50 per cent of the cadmium is lost during the enrichment of the dust and 20 to 25 per cent. remains in the residue. It is probable that the volatilization losses and the material absorbed in the muffles account for about 40 to 45 per cent. of the cadmium. Only 1.5 to 3.5 per cent of the zinc in the original dust is vaporized during removal of the cadmium.

If the recovery is 315 kilograms (696 lb.) of finished cadmium of 99.5 per cent grade each month, and if this sells for the average price of 7.75 marks per kilogram (84 cents per lb.) the total monthly receipts will be 2441 marks (\$581).

Against this income must be set the following costs:

	Marks	
1. For collection of the dust.....	90	\$22.40
2. Labor on cadmium furnace, 1 man during the day (30 days) 4.50 marks.....	135	32.10
3. Labor, part of one man's time at night.....	15	3.57
4. Disposal of residue.....	9	2.14
5. Nineteen ordinary muffles at 4 marks each.....	76	18.10
6. Twenty tons coal at 14.50 marks (\$3.46).....	290	69.10
7. Depreciation and amortization.....	50	11.90
8. Five per cent loss of zinc, at 5 cents lb.....	302	72.00
	967	\$232.31

So the net profit per month is 1474 marks, \$351.

The installation costs are as follows:

	Marks	
Furnace construction.....	1,000	\$238.00
Twenty condensers, at 5 marks each.....	100	23.80
One cast iron retort.....	150	35.70
Shears, molds, etc.....	250	59.50
	1,500	\$357.00

The life is calculated at about four years. This makes the rate of amortization per month 31.25 marks, while 50 marks was allowed in the above calculations. The iron retorts deteriorate more rapidly and the extra 18.75 marks is allowed for this purpose, although it only requires about 15 marks, leaving 3.75 marks for the necessary small repairs.

The cadmium furnace can easily be installed along one wall of the furnace room of the zinc smelter, causing very little change in the regular routine, and is as easily attended and served as the muffle tempering furnaces.

A plant of the above description would produce annually 3780 kilograms (8350 lb.), and at the above prices would bring in a net profit of about 17,688 marks (\$4,210). It is assumed that the zinc dust thus treated cannot be sold, due to lack of market or of some undesirable quality.

It can be easily seen that the making of cadmium should be very profitable business when cadmium is worth more than 7.50 marks per kilogram (81 cents per lb.). Furthermore the installation costs are low and it is easy to discontinue operations when the cadmium market is low. This is of particular advantage, and besides the small cadmium furnace is not injured in the same manner as a zinc furnace by being cooled off, and it can be easily converted into a retort tempering furnace.

Translator's Note.—Much of the metallurgy of cadmium above described is not new, and indeed a much better description of that subject is found in Ingalls' "Metallurgy of Zinc and Cadmium." However, the ease of recovery of cadmium and the small expense to which the capitalist is put in order to recover cadmium from zinc ores should be welcome news to American zinc smelting men. It is to be regretted that the commercial state of the art in the United States is such that it is very hard to get definite information on the technique of the metallurgy performed and on the present use of the product. It is known that others besides the Grasselli and the A. S. & R. companies are now marketing cadmium in the United States. Some of the A. S. & R. companies, as well as that of some of the other plants, is from the fine dusts of lead ores. Much of the present production would not be profitable, or at least would be much less profitable on 75c. cadmium. Hence the secrecy. It is to be hoped, however, that the technical advance will be such that more than 35 per cent recovery will be possible and that the number of producers will soon become such that information on the subject can be given out without imperilling the interests of the parties concerned. O. C. R.

New York Meeting of American Institute of Chemical Engineers

The sessions of the first day of the winter meeting of the American Institute of Chemical Engineers, held in New York City, from Wednesday, Jan. 10, to Friday, Jan. 12, were reported in our last issue. On Thursday an excursion was made to Perth Amboy, New Jersey, and in the evening a subscription dinner was held at the Chemists' Club. Mr. Maximilian Toch was toastmaster, and the speakers included Messrs. Olsen, Hendrick, Bakeland, and Baskerville.

On Friday morning a technical session was held at the Chemists' Club at which two papers were read. EUGENE E. AYRES, JR., of the Sharples Specialty Co., presented an able paper on "The Effect of Centrifugal Force on Colloidal Solutions." This will be printed in full in our next issue. In discussing the paper, Dr. Andrews asked whether with a solution containing particles of two different sizes, such as microns and amicrons, the removal of one size would not be hindered by the other; in other words, whether there would be a complete separation of a definite size when the force necessary to separate that size was applied. Mr. Ayres thought that in general a certain amount of another size would be carried down, but that it depended on the nature of the materials and on the electrical attraction of the particles. With some substances, a more complete separation of different size particles could be effected than with others. Dr. Richardson and Mr. McCue also discussed the paper.

The second paper was presented by Mr. CHARLES L. CAMPBELL, of E. B. Badger & Sons Co., who spoke in a very interesting manner on "Recent Developments in Distillation and Absorption." Publication of this paper in full is reserved for a future issue.

On Friday evening a technical session was held, at which the new president of the Institute, Dr. G. W. THOMPSON, read his address on "The Human Side of the Development of the Chemical Industries." The first part of this paper was printed in our last issue, and the concluding part will be found below in this issue. The paper was discussed by Dr. Frerichs, who spoke of welfare work done at his plant, especially in the matter of shorter hours, workmen's insurance, etc. He said the results obtained from better working conditions fully justified their adoption.

The second paper of the evening was read by Mr. F. W. SPERR, chief chemist of the H. Koppers Co., on the "Recovery of Benzol from Coke Oven and Illuminating Gas." This paper is printed in full on page 135 of this issue. In discussing this paper, Dr. Frerichs mentioned a distilling column used in Germany which was filled with short cuts of pipe of different diameters, as, for instance, 1 in., 2 in., and 3 in. The cuts are about as long as the diameter. A well-known manufacturer of carbolic acid in Germany has used this column with success, and a much shorter column can be used. Mr. Sperr said there was a tendency to make the column more simple, and to place more dependence on the dephlegmator. Mr. Campbell said he was familiar with the system, but not from actual experience with it. He thought it quite possible that this short column, filled with cuts of pipe, would give the same

results as a long one with plates. Mr. Peterson asked whether it was possible to recover benzol from producer gas. Mr. Sperr said he had examined one producer and did not find enough benzol to warrant commercial recovery. The possibilities of recovering ammonia, however, are very great. In the by-product coke oven about 25 lb. of ammonium sulphate are recovered per ton of coal used. It is possible to recover from 80 to 85 lb. of ammonium sulphate per ton of coal used in the gas producer.

The last paper of the evening was by Mr. ANDREW M. FAIRLIE, on "The Fairlie Method of Control of the Chamber Process for Making Sulphuric Acid." This was presented in abstract by Dr. Olsen, as follows:

The deficiencies of the old methods of controlling the chamber process are pointed out, and the Fairlie method is described. The latter



G. W. THOMPSON
President American Institute of Chemical Engineers

(technical description in U. S. Patents Nos. 1,205,723 and 1,205,724) has been in continuous daily use at the plants of the Tennessee Copper Company for six years. It consists in determining the percentage of sulfur dioxide in the chamber gases at some point near the front end of the chamber system, and in comparing such percentage with the percentage sulfur dioxide in the burner gas, before admixture with niter fumes. The comparison shows, after experience, that a certain ratio between the two sulfur dioxide percentages must be maintained in order to secure the best results in the Gay-Lussac tower. What this desirable ratio is must be determined for every possible grade of burner gas. Once determined, the desirable ratios are arranged in tabular form on a card, which is framed and secured in a place convenient for reference by the chamber operator. This operator, by taking tests frequently of the burner gas and the front chamber gas, obtains accurate information as to the speed of oxidation of sulfur dioxide in the chambers, and obtains this information in time to apply the proper remedy and to adjust correctly the proportions of niter admitted to the process, whenever anything is about to go wrong.

The usual analytical method for the determination of sulfur dioxide is altogether unreliable as applied to gas mixtures containing the oxides of nitrogen. An improved method has been devised, and this method is described in detail. Without this improvement in the method of determining the sulfur dioxide in chamber gases, the development of the new method of chamber control would have been impossible.

The Human Side of the Development of Chemical Industry*

By G. W. Thompson
(Concluded from page 81)

I think that I have said enough along this particular line to indicate to you my views as to what the chemist should do in the direction of trying to develop a popular appreciation of his work. If there is truth in what I say I am quite sure the open mind of the average chemist will discover it. If I am wrong he will soon find the vulnerable point in my argument. I would like now to pass to another aspect of this question, which relates more particularly to the chemist himself. What I have said so far deals for the most part with the attitude of mind of the chemist toward the public. What I propose to say now deals with the attitude of mind of the chemist towards himself. I have referred to a relation existing between the chem-

*A paper read at the Ninth Annual Meeting of the American Institute of Chemical Engineers, New York City, January 12, 1917.

ist and the public. In this relation there are two parties, the public on the one hand and the chemist on the other. The problem before us is: What should the chemist do to develop and improve his attitude of mind towards himself? This is an exceedingly difficult subject, and if it were not that I am fortified by a belief in its importance, I would not dare to speak upon it. I cannot think of anyone holding a higher opinion of chemistry as a profession than I do, and all that I am saying is actuated by a profound belief that the chemist is only beginning now to climb the ladder that reaches to a power of service unequalled by any other profession.

The delicacy of this subject is such that I feel impelled to approach it in the form of questions. In putting these questions, let us consider first some facts, and then we can come to the questions themselves. Let us first consider the young chemist just leaving his college or university. Like all students graduating in various courses, he has yet to learn what business life really is. They think they know what it is, but we know that there is no college or university that teaches it. The difference between the chemist and most other graduates is noticeable in this: The chemist enters a more or less isolated laboratory; most of the others go directly into the commercial world. The chemist in this laboratory—be it analytical or research—is not dealing with people, but with inanimate material things. He may stay in this laboratory a few months, a few years, or for his lifetime, as the case may be. He may be doing invaluable work, but—here is the question: Is he taking his proper place as a man in the world of men? Is he not too much isolated? Is he in his occupation gaining directly in his power over other men? Is his social instinct being developed or is it being retarded in its growth?

If we think that laboratory chemists as a general class are taking their proper place in the world in which mind reacts upon mind, there is nothing more to be said; but if we think with his intelligence and education, the chemist has a mission outside of the indirect service he professionally renders to society, then our question leads us to urge that the barriers which ordinarily isolate the laboratory chemist should be broken down so that he can get out more into the pulsating business world. He may not be able to do this alone, and perhaps the duty devolves upon us; perhaps there are some of us who have it in our power to help bring about this liberation. If we want chemists to have a greater personal influence in the world, and by this we mean to include those chemists who are subordinate to us individually, is it not proper for us to ask ourselves whether at times we do not rather selfishly stand in their way? Cannot those of us who are employers of chemists give our employees more opportunity to become familiar with the commercial aspects of the work they do? If we do this, will they not become better and more profitable employees? In our dealings with non-technical men representing large business interests, could we not more regularly and persistently ask to be brought into contact with their chemists if they have them, thereby helping to pull them out of their seclusion? If we are asked to organize a laboratory in a commercial concern, could we not say that the work of the chemist would be greatly helped if it were so arranged that he would know the actual use to which his reports were to be put? Could we not do something in urging that the laboratories in which such chemists are expected to work should not be hidden away in inaccessible places? Could we not do many things suggested by the occasion to break the bonds which the young chemist, led by false hopes, may have often slowly forged? Is it not possible that with our col-

leges to-day filled with students of chemistry, these students should be advised against accepting positions of an isolated character?

You will see that I am basing my argument on two hypotheses, which are intimately related. One is that social relationship is one of the great purposes of life, and the second is that without such social relationship no individual can really be successful in the development of any important enterprise. I have argued, therefore, that the chemist's success depends upon a social recognition of his worth, and second, that the chemist should enter into as broad social relationship as possible. In popular terms one of these means that it pays to advertise, and the other means that the chemist should get out upon the broad highway.

I propose now to say a few words on the disadvantage which is sure to result from antagonism. I propose to advocate in all our dealings a conciliatory spirit. It would seem almost unnecessary to say that if the chemist is to advertise, he should avoid offending the persons who read his advertisements, just as it is perfectly obvious that the salesman who is trying to sell goods should not make himself *persona non grata* to the purchaser. A good salesman—and that is what we should all try to be in one form or another—subordinates his own views and makes them as inconspicuous as possible, but no less effective. What he tries to do is to find out the views of his customer so that he can furnish the customer with what he desires. I wonder if sometimes chemists are not a little more pugnacious than they should be. I sympathize with the feeling of an analytical chemist who will set his results up against the world and insist that he is right, but many years of experience have taught me that the chemist who does this without regard for the effect upon other chemists is doing a very foolish thing. I believe it is a good rule never to put anybody "in wrong." I believe it is far better, even in the case of commercial opponents, to help the commercial opponent out of his difficulties rather than to push him in deeper. Again, are we not at times a little too virulent in asserting our ideas respecting public officials—administrative, legislative and judicial? They are human beings just as we are, they are representatives of the whole people, and if their views differ somewhat from ours, is it not very much better to work patiently and steadily to change their views, directing them into constructive paths, rather than to confirm them in their views and drive them to unwise extremes by opposing them vigorously?

Let us take as an illustration a subject on which perhaps chemists are divided at the present time, although the division may be by no means equal. Many chemists are seeking to have our national government help the chemical industry to become more firmly established in this country. Some think it can be done by subsidies, others by protective tariffs, others by embargoes, and so on. Now I would not argue in this meeting for or against any of these propositions. I simply say that if you are in favor of any one of them it is unwise because he opposes you to incur the antagonism of any public official, even if he be of an opposite political faith. Practically all public officials have their ears to the ground; they are trying to find out what their constituents want, and no one should blame them for this. In so far as they are representatives they are only doing their duty. It is perfectly proper for us to try to convert a public official to our way of thinking. It is still more proper for us to try to convert the people he represents to our way of thinking, but I consider it the height of foolishness to attribute to public officials dishonest purposes, ignorance, stubbornness and all the other sins of commission and omission. My

point is very clear—such accusations do not lead you anywhere but into trouble.

I believe firmly that the obstacles which we meet in our social acts in endeavoring to get our plans consummated do not differ essentially from the obstacles which the chemist meets in the ordinary routine of his work. If he finds a chemical reaction is not progressing satisfactorily, he does not close his eyes to this fact and denounce some devil or anthropomorphic god because it has interfered with his work. He tries to find the cause of the trouble and remove it. So I say that if you have social obstacles to overcome, find their cause and remove it, bearing in mind that there is no easy way by which this can be accomplished—in fact, that there is only one way—education backed by good-fellowship.

We have heard in recent years a great deal said about efficiency; it may be that some foolishness has been uttered. The word "efficiency" is used in various ways. We have the efficiency of a process considered by itself; we have this efficiency as compared with other processes; we have mechanical, chemical and human efficiency. I am interested primarily in this paper in human efficiency. What does it mean? Broadly speaking, it means co-operation without friction. Perhaps we should say that co-operation cannot be had with friction. Of course, it would be absurd for me to attempt to solve the eternal problem of human friction in a paper of this kind. All I can do is to indicate some ways by which it can be reduced. While the realization of frictionless humanity is far away, symptoms of it have certainly appeared at times. Efforts in the direction of reducing human friction conspicuously numerous at this time are to be found illustrated in factory welfare work, workmen's compensation acts, pension systems, etc. All of these have been justified by the increase in human efficiency they have produced. A man whose welfare is of no account is not a good workman.

Human efficiency, however, demands right men in the right places. The difficulty that the employer experiences is in knowing whether he is picking the right man for the place or not. If the man has been educated rightly the employer is better able to form an opinion. Particularly is this true regarding foremen and the higher grades of labor. Graduates of such institutions as give technical education are made more nearly right for places in chemical and other industries. More general industrial education such as that being advanced in some states will undoubtedly add to human efficiency. Even then the making of a man suitable for a given position comes after he commences employment and is largely the work of the employer himself.

Industries do not merely require men, however; they are complicated machines of which the men form a part. The proper fitting and adjusting of these machines to the men employed is the big problem only partly worked out as yet. Each industry has its own requirements, these requirements continually changing with the growth of society. Who has not been face to face with the requirements of an industry? These requirements are almost vitalized by competition. Industries come and industries go, they are planted and they are reaped, but their volume increases from year to year. We must not, however, allow ourselves to think of industries and industrial processes as though they were other than inanimate things. We should not waste our tears over their rejection when they are worn out, provided others take their place. This is growth—the sloughing off of the old and the putting on of the new.

The chemical engineer has a great deal to do with the development and administration of new processes.

Many an old foggy has damned the chemical engineer, who has rendered his processes and his equipment antiquated and idle. The mechanical engineer also has received his malediction. We are sorry for the old foggy and would, if it were possible, provide insurance for him, but we would do nothing to retard the fate of his equipment.

The development of a new process is the result of many separate factors. New processes are like the waves of the sea—they cannot rise much higher than the level of the sea itself. They rest on general industrial growth and are not much above the level of that growth. This is true of all processes, chemical processes included. Their growth depends upon the growth of the mechanical art, its methods of fabrication, and all the materials that enter into construction. It depends upon highly developed foundry practice, mining, building construction, farming and transportation, and last, but not least, all those branches of human development which are manifested in the home, social organization, governments and international relations. I emphasize this human factor because so many processes have had to wait years for the time to ripen for their introduction, indicating, in other words, that not alone should our endeavors be directed to the development of processes, but they should also be directed in a general effort to accelerate the coming of the fullness of time. The fullness of time means that the social level has been sufficiently raised.

New processes are of two kinds: First, those which provide improved methods for making old and well-known products, and second, those which involve the making of new products to take the place of old, or new products which serve entirely new purposes. A new process which is intended to provide methods for making an old product, if it is to be successful, must involve economy of some sort—economy of material, investment, time or labor. Necessity creates the demand for such new processes. Competition, domestic and foreign, is the impelling force. The wise manufacturer recognizes that the development of a new process may be his salvation. It is impossible in this paper to discuss all the demands which compel the invention of a new process. We will discuss only the human or labor element.

If labor here in the United States is higher in price per unit of product than it is abroad, it is manifest that with free competition the manufacturer must so modify his process that this item in cost will not militate against him. He may not be willing to modify his process, and his first instinct may be to limit the competition by a protective tariff or some similar restrictive measure. One objection to this, except as a last resort, is that it removes some of the pressure which makes for improvement of process. We may dislike the pressure, but we know after all that it is a good thing. We cannot allow anything to interfere with such pressure as makes improvement necessary. Such improvement may be possible. It is much wiser to insist that it is possible than to insist that it is not. Success is often accomplished by doing what is apparently impossible, but assuming that the manufacturer cannot get the protection he wants, how will he go about improving his process? We will offer only a few suggestions.

The first consists in manufacturing in large units. By this means overhead charges are reduced and materials can be handled more cheaply by mechanical means, thereby either directly or indirectly reducing the cost of the labor factor. In this direction it would appear that the United States has been pre-eminently successful; there is probably no country in the world which

equals us in this line of development. The second consists in subdivision and specialization of labor. It is obvious to all that it is through this method that most of our industries in his country have been successful. The third is radical development of process. If we take a given process and consider all of the operations, step by step, we are able tentatively to classify these steps into two kinds—the essential and the apparently necessary. The apparently necessary step is not by any means an essential step. An apparently necessary step is one that the state of the art has not eliminated. An essential step is one that we feel justified in saying cannot be eliminated, no matter what the state of the art is. By a radical development of process it may be possible to eliminate apparently necessary steps. The burning down of a house in order to roast a pig was in the mind of the Chinaman of fiction an apparently necessary step. It was, however, eliminated by the efficiency engineer of his day. Fourth, by doing by machinery what was theretofore done by labor. An essential step in a process may still appear essential, although instead of performing the step by manual labor it is done by machinery. This much does not involve the elimination of a step. Doing by machinery what was theretofore done by labor is the obvious method of reducing labor costs. It usually entails, however, additional cost for investment, power, and repairs, and also the employment of a higher class of labor. It is perfectly obvious that where labor is cheap machinery is unnecessary, but that where labor is high competition compels the use of machinery, and that this is the proper and natural order of things.

This is perhaps to you a somewhat academic presentation of the methods to be followed in studying how a process can be improved. If I should go into the methods by which new processes for making old or new products might be worked out, it is probable that this study would be still more academic, and I will not attempt here to touch upon that branch of the subject. What you may consider academic in what I have said, however, has a very practical bearing upon the general subject I am endeavoring to present. As I have already indicated, I am interested in human efficiency. Mechanical efficiency that does not lead to human efficiency is of rare occurrence. Considered in the most general economic terms it is doubtful if it ever occurs. It is natural for us to think of human efficiency as a means rather than an end, but I would reverse this relation and ask you to consider human efficiency as more of an end than a means. It is desirable that we should have high-priced labor because high-priced labor usually means greater intelligence and higher character.

A more highly developed social organism is one of the noblest objects for which one can work, and all efforts spent on the development of its parts is well worth while. If you believe with me that an appreciative public is necessary for the proper growth of the chemical industry, you will also agree that we need a public which shall have the power of appreciation which can only come as a result of the general raising of the level of social conditions.

The chemist by working for improvements in processes involving a saving of labor, and at the same time involving the employment of a better grade of labor, is contributing his part to the better development of a high social organism. If the chemist, however, simply endeavors to improve a process without regard to the possibility of that improved process involving the employment of a higher type of labor, then his work is incomplete. It is true that his process may with cheap labor be able to manufacture products which are used by the entire community, and which consequently can

be sold at a reduced figure and thereby benefit society, but many difficulties will lie in his path if he does not at the time that he reduces the quantity of labor necessary in the process also create a demand for a higher quality. I therefore ask those of you who are engaged in the development of processes, such development being forced by competition and the requirements of the industry, to consider whether it would not be better for you to put your mind in the attitude that in your development of process you may possibly be able to get better results by the use of more intelligent and higher priced labor than you could by sticking to low-priced labor and possibly handicapping yourself and your process and preventing its fullest development.

I have endeavored in this paper to present several aspects of a very large and important subject. Some parts of it may appeal to you and other parts may excite your opposition. In the main, however, I believe all of these parts are related to each other consistently and logically. If you believe as I do, that a better social organism is the highest purpose for which anyone can work, you will accept what I have said and include in the proposition many extensions on which I have not touched. If, however, your minds are more practical, I think you will accept many of the things I have presented to you purely on account of their practical value. Therefore from whatever standpoint you approach the subject, am I not correct in stating that practical business success in all lines of business, including those involving the use of chemistry, is dependent upon popular appreciation, is dependent upon social growth, on which the power of appreciation rests, and that everything which tends to increase the power of appreciation helps appreciation itself, and that anything that increases appreciation increases the chance of success of a business enterprise. Or to put it negatively, anything that interferes with an increasing power of appreciation, anything that tends to prevent appreciation or creates those antagonisms which operate against appreciation is pretty sure to hinder the growth of a business enterprise.

If this fundamental proposition is accepted, we can readily see how important it is for the chemist in attempting to build up chemical industry in the broad sense to do everything in his power to raise the general level of human knowledge and education and of social conditions, for it is that level that determines the power of appreciation. Assuming this power of appreciation to exist and to be growing in strength, you will also, I think, agree with me that the chemist should do everything in his power to create a greater appreciation of the value of chemistry in solving the problems of industrial life, for it is only through such appreciation that the chemist himself will be able to exert fully that ability for service which we all believe he possesses. But if the chemist is to impress himself on the public through legitimate advertising, should he not also endeavor to develop that attitude of mind which makes him continually a factor in social growth? Should he not break away from all influences that tend to isolate him, and that, if they do not make him a peculiar being, at least have the effect of preventing him from having the fullest influences over others? Should we not do everything in our power to broaden the horizon of the chemist, to increase, as it were, his circulating power in the social organism? Should we not, as chemists, by very simple methods do all we can to pull chemists individually out of all such surroundings which tend to narrow and handicap them?

Now having done all of these things, should we not go a step further and recognize the peculiar position which the chemical engineer occupies in the develop-

ment of chemical processes? Our minds naturally operate discontinuously. We think of a chemical process and its development as an independent thing, as though it were not a part of all of the other processes continually operating in society. We think that with the development of a process our work is ended; we think that with cheaper manufacture of given products we can sit down with satisfaction and consider our efforts successful. But philosophers tell us that there is no such thing as discontinuity, that everything runs into everything else continuously and is a part of a complete whole. Some fancifully have said that if a man could destroy a single atom, the universe would fall to pieces. This is fanciful but it expresses a true conception. There is such a thing as solidarity—not the solidarity of labor, not the solidarity of industry, but more surely the solidarity of society. All things operate in circles. We have continuous production and continuous consumption, in which material things circulate around and around, never completely stopping. This is so of all human affairs. Effects are unending. All the ends we work for are but the means to other ends. The development of a process was the end yesterday, but to-day it becomes a means—a means by which the social level is raised, which in its turn becomes a means by which other processes are developed.

This is why I have expressed my opinion that in the development of a process it can hardly ever be said to be complete unless it results in the substitution of quality of labor for quantity, whenever such a development has for its purpose the saving of labor. Development of a better quality of labor is essential if we are seeking broadly to increase the power of appreciation on the part of the public. It would be manifestly foolish for me to advocate that chemists should seek to impress Hottentots and Fiji Islanders with the power of service in chemistry. It would take centuries of education to bring them up to the point where we of America are to-day. It is equally foolish to think that we can expect as much appreciation from common labor as we can from intelligent labor. In saying this I make the assumption with which I hope you will agree—that every member of society, the ignorant and the wise, the poor and the rich, the bad and the good, the sick and the well, are all integrally a part of society, and each one has his individual influence in determining the average social level which measures the power of appreciation.

I have endeavored in this paper to avoid taking any position which is negative in its character. I do not believe that there is such a thing as a negative force; the nearest we come to it is inertia. I have endeavored to make positive suggestions which I submit for your consideration with the daring hope that these suggestions may find lodging places, temporarily it may be, in your minds, and if, after these ideas have stayed in your minds for a short time, they then take their flight, I have the still more daring hope that after you have forgotten them they may, though unconsciously to you, have left some faint imprint.

Volatility of Gold at High Temperature in Atmospheres of Air and Other Gases*

BY W. MOSTOWITSCH AND W. PLETNEFF

In the experiments to be described gold was used which was produced and purified by a modification of the method of Krüss (Liebig's Ann. 1887, vol. 43, p. 237). The gold was precipitated from a desilvered solution of Au Cl₃ according to Vanino and Seemann (Berl. Ber. xxxiii, 2, 1908) by means of H₂O₂ and KOH,

*Translated in abstract from the Journal of the Russian Metallurgical Society, 1915, No. 3, pp. 410 to 431.

washed and melted under borax. The experiments were conducted in a horizontal Heraeus furnace.

In the preliminary experiments 355 to 530 mg. of gold were fused for 30 minutes at temperatures up to 1400 deg. C. in an unglazed porcelain boat (which weighed 2g. and had been heated to 1300 deg. C.) in streams of dry gases of air, CO₂, CO, N₂ and O₂. The amount of gas used was in all experiments 800 cc. The volatilization was determined from the loss in weight of the gold.

The loss of gold in a stream of air was observed only by previous weighing and weighing at each temperature. The results of the tests, which were carried out at temperatures of 1100 deg., 1150 deg., 1200 deg., 1250 deg., 1300 deg., 1350 deg. and 1400 deg., are given in a table in the original Russian publication. From the tests the gold was found to undergo no loss, on melting at 1150 deg. C. for 1.5 hours, at 1200 deg. C. for 2 hours, at 1300 deg. C. for 3 hours, at 1350 deg. C. for 1 hour, at 1400 deg. C. for 2.5 hours in air.

In the experiments made in streams of O₂, N₂, CO, and CO there were no losses found up to 1400 deg. C.

In the final experiments, which were more accurate, the gold was in a chip of a quartz tube (pyrometer protection tube) which weighed 0.2 to 0.3 gram. Weighings were made on a delicate balance by means of a microscope. The gold, quartz chip and silica boat were weighed exactly, before and after heating. The gas was conducted through the furnace at a pressure of 2 to 3 mm. Hg. For each temperature the quartz chip with the gold was kept in the furnace for exactly 30 minutes.

Experiments with O₂, N₂, CO₂, CO.—Only in the first melting was a loss observed, which was caused by the gas content of the freshly prepared gold being weighed. Otherwise, between 1250 and 1400 deg. no volatilization was observed.

According to T. Rose (Metallurgy of Gold, 1906, p. 6. and Journ. Chem. Soc., 1893, lxiii, 714) this loss is considerable.

Experiments in a Stream of H₂.—Thirty tests were made in an atmosphere of hydrogen; some in purified hydrogen from a cylinder and others in hydrogen obtained from pure zinc and sulphuric acid. Up to 1100 deg. no loss was observed. From 1200 deg. on volatilization began and the loss increased with the temperature and duration of heating. The results from one series of tests using 400 mg. Au are as follows:

Temp.	Duration of Heating	Loss in Mg.	Per Cent Loss
1,250 deg. C.	25 minutes	0.2	0.055
1,300 deg. C.	25 minutes	0.35	0.090
1,350 deg. C.	25 minutes	0.42	0.105
1,400 deg. C.	25 minutes	0.98	0.250

If a curve is plotted illustrating the relation between volatility (as ordinate) and temperature (as abscissa) it will be found to rise quickly from 1350 deg. C. on. The quartz chip which contained the gold, the silica boat and the heating tube were colored an intense red, while with all other gases no color was observed. A colloidal solution of gold in quartz is formed ("ruby-glass"). In the absorption liquid (H₂SO₄) gold could be determined qualitatively.

CONCLUSIONS

1. Chemically pure gold is not volatile in atmospheres of pure air, O₂, N₂, CO or CO₂ at temperatures between 1100 and 1400 deg.

2. Chemically pure gold is volatile in hydrogen. The volatility becomes noticeable at 1250 deg. and increases with the temperature and duration of heating. What is the cause of this volatility in hydrogen? Is it a result of direct vaporization of the gold, or is it caused by the formation of a volatile compound of gold and

hydrogen? If the gold is directly vaporized, then we could also observe this phenomenon in other gases. The experiments in air, O_2 , N_2 , CO and CO_2 did not show this.

There remains the supposition that gold forms a volatile compound with hydrogen, AuH_x , at temperatures over 1200 deg. This is unstable and breaks up into $H_2 + Au$. From this the characteristic coloring of the quartz boat, tube, etc., can be explained, which is connected with the formation of a colloidal solution of the gold in the quartz or the ruby glass. This is the more probable when we consider the analogous phenomena with copper. By continued heating of copper in hydrogen, Leduc (Comp. rend., 1891, xciii, 71) observed the formation of the hyacinth red compound Cu_2H_2 , which was partly volatile. This explains also the red coloring of the refractory glass tube in which copper is heated in hydrogen in order to purify the latter from oxygen. In addition, we know a series of metals which form volatile hydrogen compounds, for example: Sb, Ba, Ge.

Tomsk, Russia.

Development in Chemical Engineering Equipment*

By H. D. Miles

President Buffalo Foundry & Machine Co.

As it is impossible in the time at my disposal to adequately describe the development of chemical engineering equipment, I shall only briefly review some of its more important phases as they have come under my observation in the manufacture of chemical equipment by the Buffalo Foundry & Machine Company, of which company I am the president.

This company was organized sixteen years ago on what at that time was considered a radical departure, namely, the operation of a modern foundry on a scientific laboratory-controlled basis. At that period the large majority of foundries were operated by rule-of-thumb methods, and no attention was paid to the chemical composition of the metals used. Metal mixtures were made on a grade basis, known as Nos. 1, 2, 3, and 4, gray forge, scrap iron, etc., the grade being determined by the appearance of its texture rather than by its chemical composition. Very little attention was paid to the percentage of different elements contained in the iron. Frequently what appeared to be a high-grade No. 1 pig iron would, when analyzed, prove to be an inferior grade.

This laboratory control established a reputation for quality and accuracy, and chemical castings, demanding the highest developed standards, immediately became one of our principal products.

It is now fourteen years since we entered this field, and for an active beginning joined issue with European manufacturers who were exporting into the United States the large pots used by caustic manufacturers, and who largely dominated the American market as the domestic product was inferior. After careful research and development, assisted by the co-operation of our customers, we were finally able to produce caustic pots of a better quality, that is, giving longer life, than those being imported from Europe.

We next turned our attention to chemical retorts of one type or another for handling different acids, and to acid eggs, and acid kettles, and ultimately obtained equal results in the manufacture of these.

After our success with these lines of chemical equipment, and several years before the outbreak of the present European war, we entered the field as manufac-

turers of vacuum dryers, pumps, and condensers, which apparatus has to-day so wide an application in the chemical field. We developed a full line of vacuum dryers, consisting of shelf dryers, rotary dryers, drum dryers, and vacuum drying and impregnating equipment, as well as the auxiliaries which go with such apparatus, namely, vacuum pumps, condensers, expansion tanks, reclaiming devices, dust collectors, etc.

This equipment, which we have highly developed with new and patented devices, is especially useful where rapid drying free from atmospheric variations is required, or where in order to avoid injury to the materials under treatment, drying must take place at low temperatures.

In this connection I wish to call attention to our vacuum drum dryers, which are constructed to dry in large quantities and at low cost without practically any loss of material, emulsions, pulps, extracts, white lead, glue, milk, acids, dyes, and other liquids containing solids. These liquids are reduced to dry forms economically and quickly and without danger of injury to the quality of the material.

We have so far manufactured five sizes of vacuum drum dryers, the smallest having a drum 2 ft. in diameter by 20-in. face, the largest 5 ft. in diameter by 12 ft. face. All sizes are so constructed that they may be easily cleaned and kept in sanitary condition, which is a vital consideration when handling food products. The smallest dryer is so constructed that the casing over the drum can be readily moved back on a track so that free access can be had to all parts of the interior. The larger types are so arranged in size and convenience that a man can enter the casing and scour all parts of the interior.

Our patented method of applying the liquid to the surface of the drum is the result of many developments in our particular machine, and the present arrangement assures a very uniform coating on the drum as well as a large output. There is a large reservoir in the bottom of the casing for holding a considerable quantity of material to be dried. This material is taken, as required, by a circulating pump located beneath the dryer and delivered to a supply pan immediately under the drum and slightly in advance of the knife or scraper which removes the material. Only a small section of the drum surface comes into contact with the liquid

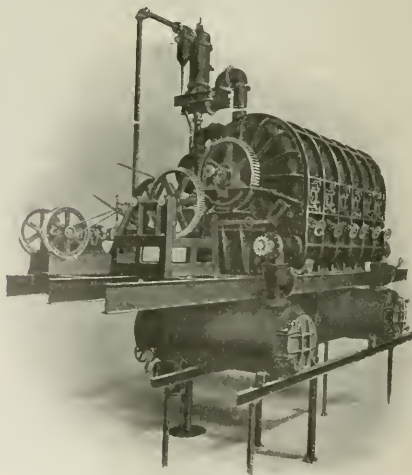


FIG. 1—VACUUM DRUM DRYER

*A paper read at the New York meeting of the American Institute of Chemical Engineers on January 10, 1917.

material and, therefore, over three-quarters of the drum surface is active at all times in drying. The material is forced in the pan under sufficient pressure to insure a uniform coating on the drum. The extra supply of liquid, which escapes on the side of the pan where the film comes out, overflows into the reservoir in the bottom of the dryer. By the time the material reaches the scraper it is dry enough for removal. It is automatically scraped from the drum, falls into a conveyor, and from there is removed to a receiver. Two receivers are used, one on each end of the machine. While one is being loaded the other is unloaded, an arrangement which permits the machine to be operated continuously.

Where the drum dips into the main body of the liquid, it is impossible, owing to the agitation and foaming of the liquid, to always maintain a constant level of the liquid material. This constant change in level results in an irregular immersion of the revolving drum surface, with a consequent variation in the moisture content of the dried product, loss of continuous service, low output and heavy cost of operation.

With our method the drum does not come into contact with the main body of liquid and, therefore, any material can be dried satisfactorily whether it foams in a vacuum or not. It is also to be noticed that as some materials give over their moisture more readily than others, the speed of the drum, and the pressure of steam used in the drum, can be varied to suit the material being treated.

One of the most extensive uses for the "Budlovak" vacuum drum dryer has been in the production of powdered chestnut and hemlock extracts. Formerly, these extracts were put on the market in a liquid state, containing approximately 50 per cent moisture. They were shipped in tank cars. These materials, with this moisture content, can be treated in our machine and dried to a powdered form, having from 5 to 7 per cent moisture content. This dried material can be packed into bags and shipped in this manner to any part of the world. By handling it in this form the market for the material is not only very much widened, but the expense and trouble of tank cars is eliminated, and consequently transportation expenses greatly reduced.

Another important use for this machine has been developed in the recovery of dry sulphite waste from the waste liquors of paper mills. This product, owing to its recovery in a dry state, now brings a handsome profit to the paper mills, and secures another by-product that can be converted to many useful purposes. It further enables the paper mills to comply, actually at a profit, with the laws prohibiting the pollution of streams with sulphite waste.

The approximate capacity of our 5-ft. by 12-ft. vacuum drum dryer on the above mentioned extracts and sulphite waste is 1000 lb. of dry product per hour. The cost of operation is extremely low. We have dried products where the cost, including depreciation and interest on investment, steam, power, labor and incidentals, has not exceeded one-tenth of a cent per pound in reducing a product from a 50 per cent moisture content to a commercially dry product under a 7 per cent moisture content.

Vacuum shelf dryers and vacuum rotary dryers have also been extensively used in the recent chemical development in this country. They can be used to great advantage in drying some of the chemicals derived from coal-tar distillates. This use is in addition to their previously extensive application in the drying of both liquid and solid materials. These dryers are also especially valuable in handling solid materials, the shelf dryer for drying sheet rubber, fruit, albumen, etc., and together with the rotary dryer, is available for use in

drying reclaimed rubber, rubber compounds, paints, dyes, extracts, pastes, glue, soap, salts, starch, vegetables, etc. Where the quality of the material is not affected by being tumbled or mixed while drying, or is not of too sticky a nature, the rotary dryer is an ideal apparatus for drying in large quantities.

At the outbreak of the present European war, when the supply of many materials never made in America was cut off, there was a sudden and large demand for chemical equipment, particularly in plants handling the many products produced from coal tar. In order to meet this demand, it was important to first make use of apparatus developed for these purposes in Europe. It was also essential to design new types of apparatus to suit conditions in this country and to make modifications in equipment which had been developed abroad.

The Buffalo Foundry & Machine Company, to its already well established engineering and consulting staffs, at once added a corps of experienced specialists who, with the co-operation of chemical engineers associated with chemical plants, developed machinery to manufacture economically the new products so greatly in demand, and we are to-day supplying apparatus for the manufacture of a large number of these products, such as aniline, acetanilide, anisidine, alpha naphthylamine, alpha-sulfonic acids, amido-naphthol, alpha-naphthol, benzoic acid, benzaldehyde, beta-naphthylamine, beta-naphthol, beta-sulfonic acids, carboic acid, dinitrobenzol, dinitro-chlorbenzol dimethylaniline, diphenylamine, Gamma acid, H acid, meta-nitraniline, meta-phenylene-diamine, meta-tolulene-diamine, metanilic acid, naphthionic acid, ortho-anisidine, ortho-phenetidine, para-anisidine, para-phenetidine, para-nitraniline, para-phenylene-diamine, para-aminophenol, phenetidine, picric acid, sulphur black, sulfonic acid, Toluidine, xylydine, trinitrotoluol (TNT), nitric acid, caustic soda, etc.

One of the first products we were called upon to produce machinery for was synthetic phenol. The methods generally used in treating sodium benzol sulphionate before fusion with the caustic soda was to take the liquor from the filter presses, evaporate it as far as possible in open pans containing heating coils and then dry the salt before fusion, either by means of heated air or by some other crude method. Seeing the field for improvement here, our laboratory started work on this problem, and it may be interesting to you to know the evolution which finally led up to the present method of operation.

We, of course, easily determined that a vacuum evaporator should be installed for reducing the liquor to a certain density, thus doing away with the open pans. The problem that presented itself, was how best to handle the evaporated liquor. Our engineers and chemists assumed that the vacuum drum dryer would be the ideal machine for treating the liquor as it came from the evaporator, but we found by actual experiment that owing to the peculiar nature of the liquor it was very difficult to secure under a vacuum a good coating on the drying drum.

We next tried the vacuum rotary dryer, but found that this machine formed the product into large cakes or balls. It was impossible to extract the moisture from the interior of these masses without spending considerable time in drying, our object here being, as in all cases, to produce the most economical method for handling a given product. We found that the experience we were having with this product coincided with that which we had had on some other products, which we worked out by using an atmospheric drum dryer for reducing the moisture content to, say, approximately 12 per cent, and then finishing the process in a vacuum rotary dryer. We found that this experiment produced

the desired results and furnished a beautiful sodium benzol sulphonate salt ready for fusing with the caustic soda. Later experiment showed that it was not necessary to reduce the moisture content in the sodium benzol sulphonate to below 12 per cent before fusing with the caustic soda, with the result that the vacuum rotary dryer has been eliminated and the atmospheric drum dryer is used exclusively for handling the liquor as it comes from the evaporator.

We later found that the "Bufokast" atmospheric drum dryer has many uses in chemical plants. The patented successful principles of operation in this dryer are the causes for its exceptional success in this field. It embodies the principles of the "Bufovak" vacuum drum dryer. The same patented automatic device for applying the liquid to the drum produces a uniform coating on the drum, and consequently a uniformly dry product. It is an ideal machine for drying materials that can be dried rapidly and without injury under atmospheric conditions, such as salts of sulfonic acid, sodium naphthalene sulphonate, and other similar products. The machine is continuous in its operation, is a great labor saver, and the finished product produced is uniform, and when desired for fusion is in excellent condition to go direct from the dryer to the fusion operation.

One of the early demands since the European war has been for a reducer for the manufacture of aniline oil. The improvements here which have been made, are the improved sludge unloading device which automatically raises the valve when open, and wedges it in position when closed, the introduction of reversible liner plates, hollow shaft and rake for the introduction of steam when desired, and the jacketed bottom for special cases.

Another development we have made is apparatus for the distilling of beta-naphthol. This consists of a still body, constructed of a special metal, and fitted with a cover in the usual way. The new features of this still is the condensing and receiving system, the condensation being drawn into an air-cooled condenser consisting of a single pipe. This pipe leads into steam jacketed, three-way valve, one of the valve openings attached to the condensing pipe, and each of the other two leads to a receiver. The steam in the jacket prevents the material from solidifying in the shelf, the material on entering the receiver passing between two glasses. By this means the operator can easily determine when it is shut off, and change from one receiver to another.

These receivers are rectangular cast-iron boxes with a door opening the full size at one side. Inside of the receiver is placed a steel box with tapered sides which fits as neatly as possible the full size of the receiver. The beta-naphthol solidifies in this box, which is easily removed and is dumped by taking out the tapered box. In addition to the foregoing, the still is supplied with a large tank in which are placed baffles to collect any

material that may pass a receiver. Beyond this tank two smaller receivers are supplied, one for containing the liquid to neutralize the vapors if any should pass this distance from the still. The other receiver is for this liquor in the event that the air current is reversed in the pipe. This allows the liquor to flow from one tank to the other as the case may be. The entire apparatus is evacuated by means of a dry vacuum pump, and the still is heated by a direct fire.

Another of our developments in the manufacture of sulfanilic and naphthionic acid and for reclaiming high-boiling-point solvents from waste is a direct-heated shelf retort, consisting of a chamber, provided with ducts passing from one side through an opening on the opposite side. Between the ducts, and inside of the apparatus, are formed shelves. The one side of this retort is provided with a door opening the full size of same. The retort can be operated either with or without a vacuum. The retort when operated under vacuum is connected with a dry vacuum pump and a condensing system between the pump and retort. The material is placed on the shelves in pans and the hot gases from the furnace in which the chamber is placed passed through the inside of the shelves. The regulation of the temperature on each shelf is made by dampers, which permit more or less of the hot air to pass through the shelf. This type of retort is far more efficient and has a much larger capacity than the previously odd-shaped affairs used for this purpose, and is much more rapid in its operation.

Another improvement that we have made is in the construction of autoclaves for the production of dimethylaniline. It has always been the practice to use an enamel or silicon lining in the autoclave, which has caused more or less trouble due to the checking and cracking and final deterioration of the enamel. This led us to develop an autoclave which uses as a liner a highly acid-resistant cast iron. The difficulty encountered in this construction was that the acid-resisting metal is more or less brittle and would not stand for the high pressure the autoclave works under in the manufacture of dimethylaniline. This led to our adopting the method of backing up the acid-resisting castings with a lead lining.

The rapid expansion of the chemical industry has brought up seriously the question of economical acid recovery plants. In this line one of the ingenious and unique developments has been the patented denitrating apparatus, which has for its purpose the distillation of nitric acid from a mixture of nitric, sulphuric and water. This particular form of construction of the machine enables this nitric to be distilled off at a high strength and reasonably free from lower oxides of nitrogen.

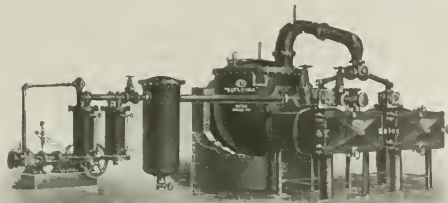


FIG. 2—BETA NAPHTHOL STILL

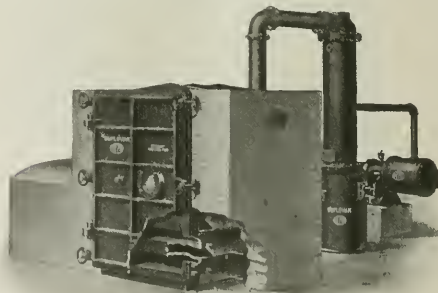


FIG. 3—DIRECT-HEAT SHELF RETORT

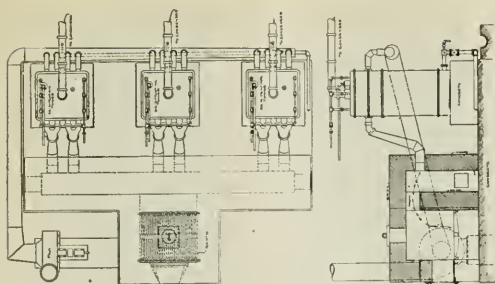


FIG. 4—DENITRATING APPARATUS

The reasons why results can be obtained from this apparatus and not from an ordinary plain still are as follows:

The new type of denitrating apparatus presents a very large heating surface in contact with the acid mixture to be treated. The temperature of that part of the apparatus above the level of the acid mixture cannot by any possibility rise above the temperature of the nitric acid vapors produced in the apparatus. By this means the strongest nitric acid vapors are not decomposed by coming in contact with superheated metal surfaces. Therefore, the very strongest acid, and fairly free from lower oxides of nitrogen, will result.

The distillation of the nitric acid is effected at a much lower temperature than is ordinarily possible. This is done by the injection of air at the bottom of the machine, which keeps the acid mixtures in violent agitation, and the nitric acid held in the mixture is removed most effectively by the sweeping effect of the air. The direct heat from the furnace is drawn through the double U pipe in the apparatus, which are always covered with acid. By this means the greater part of the heat is directly absorbed and the balance of the heat contained in the flue gases after leaving the double U pipes is drawn around, thus giving additional heating surface and giving the greatest degree of efficiency in operation. The distillation of the nitric acid is therefore effected under almost ideal conditions, and by the use of the air the factor of mass action (which has to be considered in an ordinary still when nearly all the acid is distilled off) does not occur in the new type of apparatus. By this I mean that when the ratio of sulphuric acid to nitric acid toward the end of a distillation becomes so great that a very high temperature has to be carried in the still, the nitric evolved must necessarily be weak.

For example, in handling a guncotton displacement system the first run-off of spent acid is, of course, reinforced with nitric and oleum, but the second displacement, which consists of approximately 18 per cent nitric, 60 per cent sulphuric and 22 per cent water, if placed in the ordinary still will only give a nitric acid on distillation of about 78 per cent to 80 per cent HNO_3 , and even at that the temperature has to be carried to about 180 to 190 deg. C., and in a fraction of the time taken by the ordinary methods.

It is well known that from guncotton-spent acid, and particularly where oleum is used in making acid mixtures, enormous quantities of sediment will fall down to the bottom of an ordinary still, which is difficult to handle, as it tends to choke the whole system. Now, in the new form of denitrating machine, after six months' work, there is not the slightest indication of sediment forming in the machine, and this can be readily understood, as the acid is kept in violent agitation during the whole time of distillation, which prevents the set-

ting of the mud always occurring in the ordinary still.

As to the kind of acid mixture best suited for this new type of machine, I would state that any acid mixture containing a nitric content above 2 per cent can be readily handled, and the nitrous contained in the acid mixture is to some extent oxidized by the large volume of air passing into the machine.

As air is used in this machine, which, of course, means that it is saturated with nitric acid to an extent determined by the temperature at which the air vapors pass through the condensers, some form of tower is absolutely essential in order to deprive the air of the nitric acid. The best form of tower for this purpose is a small one through which a very small quantity of water is allowed to trickle so that a fairly strong acid can be obtained at the foot of the tower, and no nitric acid allowed to escape at the top. An ordinary form of absorption tower can be used for this purpose and need only be quite small, 5 ft. high by 18 in. in diameter is quite sufficient.

As to the commercial value of this apparatus, as it refers to the handling of waste acid, one may sum this up in the following statements:

A stronger and higher grade of nitric acid can be obtained by the new machine than by any of the older processes.

The fuel efficiency per unit of nitric obtained is exceedingly high.

The capacity of the new machine per unit weight of acid handled is very much higher than with the old type of still.

The space occupied by the new apparatus is only one-sixth that required by the older type of still.

The life of the new type of apparatus is infinitely greater than the old type of still, as with the new form of apparatus only strong acids come in contact with the metal, and that at lower temperatures.

Some improvement has also been made in evaporators for the chemical and other fields which has been of great advantage in the development of chemical plants, which started with a small capacity and later desired to increase their production.

The "Buflovak" evaporator has the advantage that it can be doubled in capacity by merely inserting an additional belt and new tubes. This takes up very little additional floor space and gives 100 per cent more capacity.

Another development, which has met with considerable favor in chemical plants, has been the adaptation of the "Buflokast" crystallizing pan to many uses in the drying and crystallizing of products which tend to be sticky or gummy in the drying process. This crystallizing pan has been very efficient for concentrating and crystallizing material, permitting high temperatures. It has been used heretofore almost exclusively in this country for evaporating and neutralizing liquor of ammonia and nitric acid, and drying and crystallizing the finished product. This pan has also been equipped to operate under vacuum, which provides a means for the drying of sticky materials at low temperatures.

A recent development in equipment for handling acids is the so-called acid-proof or acid-resisting castings, which were first made in England and later in the United States. In the United States we have kept pace with this movement and have manufactured not only small pipes as a substitute for stoneware for conducting acids, but have made various shapes and sizes of re-torts. It is only recently that medium sized castings have been made with this metal. On account of the brittleness of the metal the problem from a foundry standpoint is a very difficult one, but advancement has been made, both in the size of the castings and in the shapes of them for acid work. No doubt the next two

or three years will see a considerably greater improvement in the quality and size of this equipment. I believe that as large and difficult castings are now being made in this country, if not more difficult ones, than in Europe. The use of castings made of this metal is bound to greatly increase on account of such castings being superior to enameled equipment and stoneware for many classes of work.

The Buffalo Foundry & Machine Company has for some years had a chemical laboratory and a physical laboratory for work required in the carrying on of its business. We are now erecting a large laboratory building, and will add very materially to the equipment already in use, not only in order to conduct many tests in our experimental dryers and evaporators, but also for research work in organic chemical lines. We expect that there will be a demand for new apparatus to handle the enlarging field of chemical products, and we hope to be able to serve in this development by having a properly equipped laboratory and competent engineering talent to carry on some of the research work.

However, as the old proverb says, "necessity is the mother of invention," it is important, first, to know what is required before apparatus can be designed for meeting new requirements. In the manufacture of chemicals, it is the man in charge of the plant who meets these new problems and who can call upon the research and designing engineer for his services in solving. It is, therefore, important that the chemists in charge of the manufacture of chemical products co-operate with the machinery manufacturers in speeding the advance in the design of machines to meet new conditions. It is true that great secrecy surrounds many of the chemical manufacturing processes in this country, and where publicity would effect the earnings of chemical companies it is wise to avoid undue publicity. But giving due regard to the protecting measures required, I believe it is nevertheless possible for manufacturing chemists to submit many problems to the manufacturers of chemical equipment, which the latter can solve to the benefit of both sides of the industry.

Buffalo, N. Y.

The Youngstown Chemists' Club has been recently organized, and the following officers were elected: President, Mr. Edwin G. Pierce, Consulting Chemist; secretary, Mr. Carl Weesner, Carnegie Steel Co.; treasurer, Mr. H. E. Moyer, Brier Hill Steel Co.

The first regular meeting Dec. 14, was a symposium on the local water situation. The Club is considering plans for a home of its own.

The Schaffer Engineering & Equipment Company, Tiffin, Ohio, has finished an installation of a No. 20 Poidometer with Liquid Measure attachment in one of the plants of the LaCled-Chrissy Clay Products Company, St. Louis, Mo., and has an order for four more from the same company.

The present installation is handling a mixture of ground fire clay in a predetermined amount, delivering same by actual weight and adding thereto, the right proportion of water, all of this being accomplished automatically and with a decrease in labor cost at this particular station.

Increasing Use of Coke as Boiler Fuel in England.—The London County Council has ordered 8 coke-burning mechanical stokers for the Greenwich power station. These will have a capacity of 100 tons of coke in 24 hours. The economic reasons for burning coke instead of coal and thus saving the valuable by-products incident to coke manufacture, are being increasingly appreciated in England.

A New Electric Zinc Smelting Process

Dr. Charles H. Fulton, of the Case School of Applied Science, Cleveland, Ohio, has been known for some time to work on the development of a new electric-furnace process for zinc smelting, for which various advantages have been claimed. The first authoritative information on this process has now come out through the granting of U. S. patent 1,213,180 (January 23, 1917), to Charles H. Fulton (assigned to David B. Jones, of Chicago).

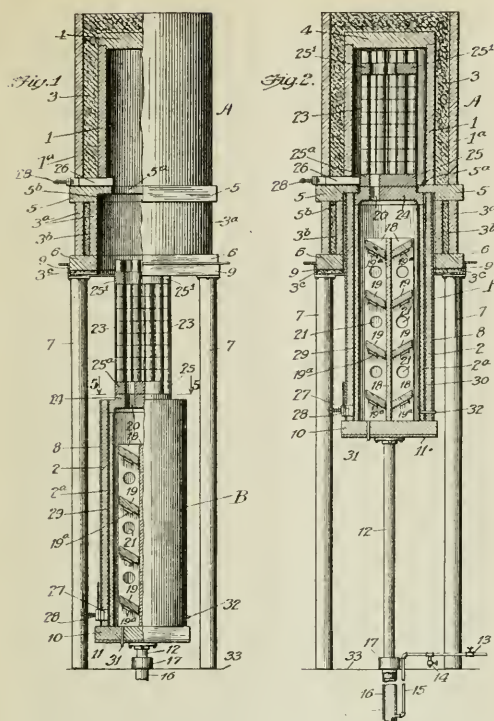
A resistance furnace is used and the charge itself is the resistor, but the novel feature of the Fulton process is that the charge is made up into briquets which preserve their form and volume during distillation. In the closed retort chamber the briquets are placed so as to form a continuous resistor between the electrodes; the heat is developed uniformly within the resistor without local overheating.

The briquets are made up of 50 to 60 per cent by weight of ground and calcined ore, 30 to 40 per cent of pulverized coke, and 10 to 20 per cent of finely ground hard coal-tar pitch. After a uniform mixture of the three constituents has been obtained, the mixture is heated to the melting point of the pitch, which melts and softens in place and thoroughly coats each article of ore and coke. The mixture is then formed into briquets of cylindrical shape in suitable molds, in which they are subjected to a high pressure, upward of 500 pounds to the square inch, to solidify the mixture.

The briquets are next preheated for the purpose of driving off the volatile hydrocarbons of the binder (which would dilute the zinc vapor in the subsequent distillation and interfere with condensation). For this purpose the briquets are subjected to a gradually rising temperature reaching from 400 to 600 deg. C. in a reducing atmosphere (by embedding the briquets in finely crushed coke). It is even advantageous to raise the temperature to 650 or 700 deg. C. in order to convert the briquets into better conductors of the electric current. The structure of the briquets produced in this manner is that of a large number of ore particles embedded in a coke matrix, this matrix being made up of the original coke and the coke left by the distillation of the pitch binder. Such briquets have a specific resistance of 0.03 ohm per cubic inch.

Fig. 1 is a view of the furnace, with the lifting means by which the briquets are lifted into the distillation chamber or retort shown in its lower position, as it would appear either immediately after the distilled briquets have been withdrawn from such chamber or immediately before the undistilled briquets have been raised into it; Fig. 2 is a corresponding view, showing the briquets lifted into position in the distilling chamber. A is the distilling chamber with the vertical columns of briquets 23 and the electrodes 25 and 25' at their lower and upper ends. B is the condenser.

Figs. 3 and 4 are horizontal cross-sections through the distilling chamber at the points of the lower and upper ends of the briquet columns respectively. In the illustrations there are shown twelve vertical columns of cylindrical briquets 23, constituting a "charge" for the retort A, and as the furnace is designed for use with a three-phase alternating current connection of the Y-type (star type) the columns of briquets are arranged in six pairs. The columns of briquets rest upon the graphite electrodes 25 and 25', which in turn rest upon the tile-block or grid 24 which constitutes the closure for the upper end of the condenser B. The three electrodes 25' (Fig. 3) each support two columns of briquets and are located at equidistant points around



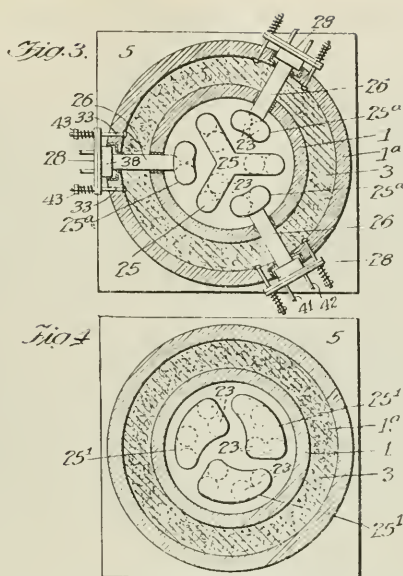
FIGS. 1 AND 2—VERTICAL CROSS-SECTIONS THROUGH DISTILLING CHAMBER A AND CONDENSER B

the block 24 adjacent the periphery of its upwardly projecting circular central portion, while the electrode 25 is a three-armed neutral point electrode, two columns of briquets being supported upon each of its three radial arms, as shown. Current is conveyed to the electrodes 25^a by three graphite electrodes 26.

At the tops of the columns of briquets the adjacent pairs of columns are connected in the manner shown in Fig. 4 by the electrodes 25', each of which is suitably shaped to rest upon and electrically connect the tops of two adjacent pairs of columns.

If we take, for the purposes of explanation, the current conveyed to the left-hand pair of columns of briquets in Fig. 3 by the left-hand electrode 26 there shown, the current will pass upward through said columns of briquets to the electrode 25' which rests upon their upper ends (Fig. 4), thence through said electrode to the upper end of the adjacent pair of columns of briquets, thence downwardly through said columns to the radial arm of the electrode 25 upon which said columns rest, being the upper left-hand arm of said electrode in Fig. 3, thence to the neutral point at the center of said electrode. The passage of the current for the other pairs of columns of briquets is similarly all convergent on the neutral point of the electrode 25, which gives the common Y-connection of the alternating three-phase current.

The current is supplied to the distilling chamber from an adjustable-voltage transformer. The amount of current passed through the briquets is preferably at first relatively small, so that the walls 1 of the retort A will be heated rather gradually to about 700 deg. C. or 800 deg. C. by radiation from the briquets. The cur-



FIGS. 3 AND 4—HORIZONTAL CROSS-SECTION THROUGH DISTILLING CHAMBER AT BOTTOM AND TOP OF BRIQUET COLUMNS RESPECTIVELY

rent may then be rapidly increased and the briquets raised to a distilling temperature. The zinc vapor then freely evolved will fill the retort space and pass down between the electrodes 25 and 25^a and through the openings 20 in the block or grid 24 into the condenser B. By means of carbon resistors in the shell the condenser is kept at a temperature between 500 deg. and 650 deg. C., the higher temperature obtaining near the top and the lower near the bottom. The zinc vapor strikes against the condensing plates 19, and circulates between the same and the walls 18, as well as through the openings 21 and in the annular space 22 surrounding the walls 18. The large surfaces afforded by these parts and the interior walls 2 of the condenser serve to rapidly condense the zinc vapor into liquid zinc, which collects in the bottom of the condenser. The carbon monoxide gas evolved in the distillation of the briquets passes out and burns at the opening 32 in the bottom of the condenser. The liquid zinc is tapped off at the tap 31. When the briquets are completely distilled, which is indicated by the dying down of the flame at the opening 32, the condenser is lowered by means of the hydraulic apparatus into the position shown in Fig. 1, and the briquets then quenched rapidly with a spray of water and removed from the grid 24, a fresh charge put in their place, and the condenser again raised into distilling position and the described operation then repeated.

Ceramic Engineering.—The Department of Ceramic Engineering of the University of Illinois, Urbana, Ill., will issue shortly a new bulletin describing in detail the courses, both graduate and undergraduate, which it offers in ceramic engineering and ceramic chemistry. The bulletin will also contain an illustrated description of the new laboratory and its equipment, and a list of the names and addresses of the graduates of the department since its establishment.

A Method of Determining the Density of Flue Gases*

By James Alex. Smith

Engineers, whether power, metallurgical or manufacturing, can always ascertain the density of the gases within their province, either by chemical analysis or precision weighing. But it is not always essential to know the chemical composition; or the composition may be deducible with sufficient accuracy if the density is known. Then methods of a simpler or more direct character have a use, particularly when it is desired to study cause and effect concurrently, and without any appreciable intervening interval during which the cause might vary.

The purpose of this paper is to describe a mode of determining gas density by gage reading. So far as the writer is aware, the method is new.

General Principles.—The basic theorem is that the densities of gases and their pressures per unit area of base are directly proportional when the gas columns are of equal height. Hence, if a column of air in a vertical tube of known height is displaced by a given gas, the barometric and thermometric conditions remaining constant, the densities are in the simple ratio

$$D = \frac{P \pm P'}{P} \quad (1)$$

when

D = Density of the given gas referred to air taken as unity,

P = Known air pressure due to column height, and
P' = Difference ($\pm$) of pressure due to gaseous displacement.

Pressure Measurement.—Assume that an accuracy within 1 per cent of the total air pressure due to the vertical or column height is required; in other words, that a pressure due to the air in a column the one-hundredth of the height of the column in the given case must be evaluated. This order of minuteness of magnitude at once contraindicates mechanism subject to friction, and indicates the use of "frictionless" liquid gauges.

Postulating that, without the introduction of undesirable complications, 0.02 in. is the smallest significant difference of level of such a gage, then the relation of that minimum gage space to the minimum correlated gas-tube height (h) is given by the equation

$$h = .02 \text{ in.} \times 100 x \quad (2)$$

when x is the specific gravity of the gage-liquid referred to air as unity. Therefore water, which is about 772 times heavier than air, if used in a simple siphon gage, and under the conditions postulated, requires a complementary gas-tube not less than $0.02 \text{ in.} \times 100 \times 772 = 1,544 \text{ in.} = \text{about } 130 \text{ ft. in height.}$ Conversely, if the height (h) in inches be given, then the maximum specific gravity of the possible gage-liquid (air, as before, being taken as unity) is determined by the formula

$$x = \frac{h}{2} \quad (3)$$

Any convenient value may be assigned to h . Let, then, the vertical height of the gas column be 100 in. Then x = specific gravity 50. That is, for such a tube height, a liquid is indicated not more than 50 times

heavier than air, or, $\frac{772}{50}$ 15.44 times lighter than water.

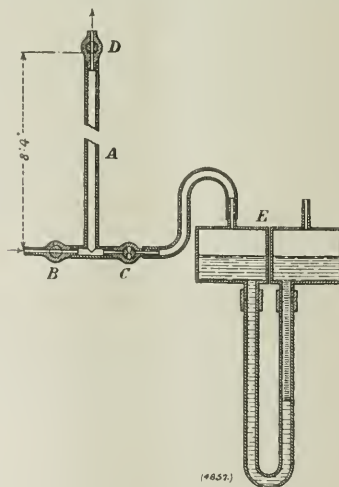
No such light liquid is known; but its equivalent may be attained if two immiscible liquids are caused to partially equilibrate each other in such a manner that the difference (which may be made as small as desired) of the specific gravities becomes the measure of the equivalent specific gravity of the liquid system as a whole.

A gage on the differential principle, capable of readily dealing with gas pressures of the small magnitude in question, has already been described by the author in the "Proceedings" for November, 1909, vol. x, page 155, under the title, "A Simple, Sensitive, Two-Liquid Differential Gage for Measuring Small Pressures."

Gas Tube.—The gas tube is very simple. In the example illustrated it consists of a piece of $\frac{1}{8}$ -in. wrought-iron gas-barrel, A, 100 in. in height. At the bottom two stopcocks, B, C, permit alternative connection to a gas-source or to a gage, E. To check diffusion the passage through the latter cock should be reduced to a pin-hole. At the top a third cock, D, opening into the air, permits the tube to be gas-flushed and filled, and when the main passage is closed continues the connection by a minute by-pass large enough to preclude any possible barometric difference of pressure between the gas inside and the air outside the tube, yet so small that diffusion is negligibly slow. The surface of the liquid in the gage cistern and the bottom of the gas tube must be approximately at the same level.

Calibration.—If the gage constants are unknown, a simple, comprehensive calibration covering all the factors can be effected thus: All parts being filled with air, adjust the gage to zero. Then displace the air in the tube with any easily generated or procured gas of known density, for instance CO_2 , the specific gravity of which is 1.524. Then the pressure upon unit of base of 100 in. vertical of CO_2 is equal to the pressure of $100 \times 1.524 = 152.4 \text{ in. of air.}$ Therefore, the consequent liquid displacement due to the displacement of the air by gas is equivalent to that which would be caused by an air pressure of $152.4 - 100.0 = 52.4 \text{ in.}$ The scale can be graduated or interpreted accordingly.

Corrections.—When relativity only is required, corrections may be dispensed with. The case of the im-



A—Gas tube. B—Inlet gas cock. C—Gage cock. D—Outlet gas cock. E—Differential gage.

NOTE.—The barometric equalizing vent (at D) is not shown. It consists of a piece of clockmaker's "bushing wire," 1 in. long and $\frac{1}{80}$ -in. bore.

* A paper read before the Victorian Institute of Engineers and published in *London Engineering*.

mediate effect of draught volume variation upon chimney-gas density is an example.

But if absolute readings are required, and if the barometric and thermometric conditions differ from those which may have been assigned in respect to P (formula 1), and upon which the value of the gage divisions is computed, then a corrected value P'' must be substituted for observed P' in formula (1); then

$$P'' = \frac{(461 + t) 29.92 \times P'}{461 \times b} = \frac{(461 + t) \times P'}{15.41 \times b} \quad (4)$$

when

t = Observed temperature on Fahrenheit scale,

b = Observed barometric pressure in inches,

P' = Observed pressure due to gas displacement, and

P'' = Corrected value of observed displacement pressure.

Strictly, a further correction should be made to compensate for the variation in the gas system volume, due to the movement of the liquid in the gage. Usually, however, this amount is so small that it may be neglected in practice.

Scales.—The actual graduations may be in any convenient terms, i.e., density or specific gravity, percentages, or direct evaluations of the major object of the test.

Variants.—(i) The mode is equally applicable in the case of density change due to chemical reaction other than combustion.

(ii) In the case of inconveniently high tubes, all adjustments may be brought within operative reach by constructing the tubes as an inverted $\cap$ providing that the minute equalizing vent must then be placed at the vertex, and must remain permanently open.

(iii) A gas tube within a chimney and extending to its full height affords a means of ascertaining the density of the chimney gases at the mean temperature within the whole stack. From this may be deduced the potential ascensional power of the gases, a result not given by the ordinary draught gages, which show the utilized value only.

(iv) Obviously portability can be attained by constructing the tube in screwed sections.

(v) Photographic continuous records can be attained by the use of any of the well-known devices. This implies a constant passage of gas, therefore precautions must be taken against the vitiation of the results by the introduction of extraneous pressure head, either by periodically cutting off the gas supply, or by making the inlet very small in comparison with a relatively large outlet permanently open. Necessarily there will be a lag in the records in respect to time.

Synopsis of Recent Metallurgical and Chemical Literature

Rubber

Vulcanization of Rubber.—The researches of the eminent Russian chemist I. I. OSTROMYLSKI, originally published in the *Journal of the Russian Physico-Chemical Society*, were translated for the *India Rubber Journal* (England) and published in its Sept. 30, 1916, issue. They have been republished in the *India Rubber World* for Nov. 1, 1916. The papers describe a most interesting set of researches on the vulcanization of rubber without the use of compounds containing sulphur. Up until the present investigations were made no method of vulcanizing caoutchouc was known in which a sulphur free organic or mineral compound was used. The chemical and physical theories of vulcanization suggested a whole series of such compounds, and Mr. Ostromylski has succeeded in discovering by

the application of physical chemistry two new methods for hot vulcanization. From a consideration of the properties of sulphur in oxidizing ethylenes, melting point, vapor pressure at the temperature of vulcanization, and other properties, substances were found having similar properties which would effect the vulcanization of rubber. Among these is 1:3:5 trinitrobenzene, and also other nitro-compounds, perbenzoic acid, gaseous oxygen, and various peroxides, per acids, etc. The work of Ostromylski is a most interesting and valuable contribution to the chemical industry, and a study of the chemical principles involved is very interesting. His work leads to a more rational explanation of the mechanism of vulcanization.

Natural Gas

Conservation of Natural Gas in Oil Fields.—A description of a process for the prevention of natural gas waste in oil fields is given in Bulletin 134, recently issued by the Bureau of Mines. The authors are JAMES O. LEWIS and WILLIAM F. McMURRAY.

"One of the most shameful wastes of this country's natural resources has been that of natural gas in the oil fields," the authors state. "This waste has been occasioned very largely by not having efficient and cheap methods of controlling the gas, nor adequate laws and regulations to enforce the control.

"Soon after the establishment of the Bureau of Mines investigations were started with the view of finding means of lessening this waste. In 1913 engineers of the Bureau of Mines were sent to Oklahoma to investigate the waste and to recommend methods for its prevention. These engineers recommend the mud-laden fluid system, which had been previously used in Texas and California, and demonstrated that the method was equally applicable to the conservation of gas in the Mid-Continent and Eastern fields."

Bulletin 134 consists of three parts. The first part covers the theory of the process and the manner in which it is used, so that the operator will understand the principles and be able to use the process even though he has had no previous experience with it. There are numerous figures illustrating apparatus and showing conditions under which the process has been used. The bulletin shows how mud-laden fluid may be used advantageously to conserve the oil and gas, shut off water, overcome high gas pressures, prevent fires and accidents, drill through loose and caving formations, save casing, and to protect casing against corrosive waters. It tells how many sources of trouble, danger and expense may be eliminated. The latest apparatus and methods, including the circulator method of drilling with cable tools, are given.

In the second part are accounts of many demonstrations of difficult cases in the Mid-Continent field. In many instances these demonstrations were made after all other methods had failed. Demonstrations were made in overcoming high pressures, in saving casing, in protecting formations, and in overcoming other difficulties. The method has now been used in several hundred cases in the Mid-Continent field. It has been the means of conserving an enormous quantity of gas, and has made possible the practical enforcement of conservation by the State and Federal authorities in Oklahoma.

In the third part are given copies of the oil and gas conservation laws of Oklahoma, and the regulations governing oil and gas operations on restricted Indian lands, which are under the supervision of the Federal government. The main purpose of this paper is to demonstrate practical means for conserving oil and gas, and these laws and regulations are included to show what technical principles should be embodied in laws and regulations to enforce conservation.

Copper

Metallurgical Operations at the Chile Exploration Co.—C. A. Rose, in the August, 1916, number of the *Teniente Topics*, pages 19 to 23, gives a very interesting description of the metallurgical work done at Chuquicamata, Chile, by the above-named company. The process used was worked out at Perth Amboy on a 15-ton plant basis by E. A. Cappelen Smith, and it is claimed by the author that the process as now used on a 10,000-ton scale works as satisfactorily as on the small scale. The commercial copper ores treated are chalcocite, covellite, brochantite, chalcantite, kroenkite, atacamite, chalcopyrite, bornite and enargite.

The plant as it is now operated may be divided into the following units: crushing plant, leaching plant, dechloridizing plant, pumphouse, electrolytic tank house, smelting and melting plant. The crushing plant consists of two No. 10 McCully gyratory crushers, two 48-in. Symons disc crushers and eight 54 x 20-in. high-speed rolls. Construction is now under way for the installation of two 84 x 60-in. Superior jaw crushers to relieve the overburden which was, up to date, thrown on the original crushing plant. Additional grizzlies and screening appliances are also being installed in order to by-pass the fine material around each crusher and to return to the rolls the oversize from the final product delivered to the leaching plant. It is expected that with these improvements the full tonnage of 10,000 tons of $\frac{1}{2}$ -in. material will be supplied to the leaching department.

In the leaching plant are six leaching tanks, each 150 ft. long, 110 ft. wide and 16 ft. high, and nine solution tanks set on a somewhat higher level. All tanks are set end to end and are built of reinforced concrete lined with 1 to $1\frac{1}{4}$ in. of mastic asphalt. The mastic consists of one part of Trinidad asphalt and four parts of sand. After melting the asphalt, it is mixed with the sand in a Gulich asphalt mixer, and after thorough incorporation is poured, while still hot, between steel forms and the sides of the tanks. The steel forms are built in sections as the lining of the tanks is cast. On the sides of the vats the mastic is kept in place by means of expanded metal laths embedded in the mastic and anchored to the sides of the tanks.

The false bottoms of the leaching tanks are constructed of 6 x 6-in. timbers, laid 10 in. apart on the floor of the tank. Above these and laid crosswise are placed planks 2 x 6 in. and 3 in. apart. This structure is then covered with cocoa matting, which in turn is covered by 2 x 6-in. planks, $\frac{1}{2}$ in. apart. On starting operations a 1-ft. layer of coarse material is spread over the false bottom. On discharging the tank this bottom layer is left intact and forms a very satisfactory sand filter. Eight 6-in. outlet pipes are distributed evenly around the bottom of each tank. These pipes unite in a 15-in. main leading to the pumphouse. The pipes conducting acid solutions are lead-lined iron pipes, joined with standard flanges and rubber gaskets, which take up the expansion and contraction due to any temperature changes in the weather conditions.

In the process of leaching, a portion of the last solution drawn from the tanks is removed for complete deposition of the copper. This amount is so calculated as to compensate for the increase in total volume of the solution, due to the addition of more water as a last wash on the ore than is discharged as moisture in the residue, and also removes from the system continually the impurities that are introduced by the ore and accumulate in the solution. After freeing this portion of the solution from copper, it is

discarded. The essential impurities are the sulphates of sodium, potassium and magnesium. When these have accumulated to the extent of 150 grams of sodium sulphate, 10 grams of potassium sulphate and 65 grams of magnesium sulphate per liter, the discarded solution in each cycle removes the same quantity of these salts as is introduced into the system by the quantity of ore leached. Iron sulphate does not seem to accumulate to any great extent in the process. Any possible chlorine, which might enter the solution, is previously taken care of in the dechloridizing plant.

After filling a tank with ore, the first solution is introduced by upward percolation, preventing thus the fine particles of ore to drop on the bottom, which would be the case if the solution were applied from the top. After allowing this solution to remain in contact with the ore for 36 to 48 hours, it is drawn off and replaced by downward percolating new solution.

The solution withdrawn for the precipitation of the copper contains about 6 per cent of the total copper content, extracted from the ore. The copper thus obtained is either cast into soluble anodes and used in the electrolytic tanks for making starting sheets or is delivered to the dechloridizing drums for the precipitation of cuprous chloride. The acid lost in the discarded liquor and also in the removal of the acid element chlorine in the dechloridizing plant is nearly equivalent to that gained from the copper sulphates chalcantite and brochantite, provided the ore has a copper content not less than 2 per cent and does not exceed 0.2 per cent chlorine. However, an acid plant is in connection with the works, so as to supply any excess acid if needed. This is simply a precaution and not a necessity at present.

The dechloridizing plant comprises 22 tube-mills 30 ft. long with an internal diameter of 4 ft. They are built of $\frac{1}{2}$ -in. steel shells lined with thin lead and with an inside shell of earthenware set in asphalt mastic. They are filled nearly half full with granulated copper and revolve at 8 r.p.m. Gravity flow conducts the solution from the solution tanks to the dechloridizing plant, where it is divided to supply the 22 tube-mills. The chlorine on its passage through the mills forms cuprous chlorid, which remains in the solution finely divided and is carried on by the stream of solution into seven Dorr thickeners. The pulp is dewatered in these thickeners, so that only 50 per cent moisture remains in the product. This product is then delivered to an Oliver filter and the cake thus obtained is sent to the smelter, where it is mixed with limestone and coke and smelted in a blast furnace. The furnace products obtained are black copper and calcium-chloride slag.

Various treatments of cuprous chloride have been tried, such as smelting, electrolysis and cementation, and it has been decided that the cementation was most beneficial under the circumstances of the operation of the plant. This decision is due to the amount of cement copper required in the dechloridizing mills. The cuprous chloride will be dissolved in brine solution and the copper precipitated on scrap iron. The amount of iron used will be approximately half of that used in the ordinary cement copper processes, due to the fact that the copper is present in the cuprous and not in the cupric form. Part of the ferrous chloride formed in the process will be used for dissolving more cuprous chloride instead of using salt.

The clear solution from the thickening tanks is pumped to a large, asphalt-lined concrete storage tank of 1815 cu.m. capacity. From here the solution is conducted to the electrolytic tank house by means of

gravity. The novel features of this part of the process consist in the use of magnetite anodes, asphalt-lined cement electrolytic tanks and launders, the use of large-sized cathodes (3 ft. x 4 ft.) and the cascading of 16 tanks in one solution circuit. Since the outbreak of the war in Europe the magnetite electrodes have been replaced by such made of duriron, as it was impossible to produce the fused magnetite electrodes locally or in the United States, Germany being the only place where electrodes of this type could be purchased. Duriron electrodes answer the purpose fairly well, resisting the dissolving action satisfactorily, but not as well as the fused magnetite. They surpass the magnetite electrodes in strength, but have a much higher over-voltage, which is a decided disadvantage. Duriron electrodes require about 15 per cent more energy than do magnetite electrodes for the deposition of the same amount of copper. This excess energy goes into heat, and at times this heat becomes so high as to soften the mastic lining of the tanks.

The purity of the copper produced is approximately 100.5 to 101 per cent Matthiessen's Standard, being somewhat higher than that produced in American electrolytic refining practice.

Gallium

Electrolysis of Gallium Solutions.—A contribution from the Physical and Chemical Laboratories of Yale University on the production of gallium "trees" is given by HORACE S. UHLER and PHILIP E. BROWNING in the American Journal of Science for November, 1916.

During the process of separating metallic gallium from an alkaline solution by electrolysis it was noticed that black coral-like deposits sometimes formed around the cathode instead of the bright liquid globules which were expected.

The electrolyte used was obtained in the following manner: Lead residues were shaved into small pieces with an ordinary iron ice-plane and dissolved in a solution made from equal volumes of water and strong nitric acid. On cooling, most of the lead crystallized out as the nitrate. Concentrated sulphuric acid was then added to the filtrate and the resulting liquid was evaporated nearly to dryness. The insoluble lead sulphate was removed by filtration after the addition of water. Silver was next precipitated as the chloride by treating the filtrate with hydrochloric acid. By adding an excess of ammonia to the filtrate the hydroxides of gallium and indium were thrown down while most of the copper and zinc compounds were kept in solution. When working with large masses of material it was found necessary to repeat the last operation in order to effect a satisfactory purification of the hydroxides of gallium and indium. Finally, these hydroxides were separated from each other by taking advantage of the facts that indium hydroxide is insoluble in a solution of sodium hydroxide, whereas gallium hydroxide is readily soluble in an excess of caustic soda. The filtrate thus obtained constituted the electrolyte used in the cells. Each step was checked spectroscopically and found to produce satisfactory and efficient separations.

The electrolytic cells consisted of the following assemblage of very simple parts. The vessel containing the liquid was an ordinary glass crystallizing dish 10 cm. in diameter and 6.3 cm. deep. The anode was a thin rectangular sheet of platinum foil, the edges of the submerged portion being 5.5 cm. horizontally and 3.5 cm. vertically. The cathode consisted of a platinum wire sealed into a glass tube with about 2 mm. projecting at the lower end.

The current used was 0.28 ampere. The trees were

formed at about 0 deg. C. and the cell was cooled with ice. The gallium trees closely resembled certain arborescent forms of native copper.

Recent Metallurgical and Chemical Patents

Iron and Steel

Open-Hearth Steel Process.—A process for the manufacture of steel by the basic open-hearth process is patented by ALFRED E. DAVIES of Bilston, England. The process consists in coating the bottom and sides of the basic lined bath of the furnace with a special slag, after the metal of a previous charge has been tapped out. The method as used in practice is given as follows:

"Assume that there is in the furnace a molten charge of metal and slag which has been partially worked in the usual way until the bulk of the silicon and phosphorus in the metal has been removed, the slag is then tapped off by tilting the furnace and further additions of lime, iron ore and oxides are made to the furnace, in order to remove the last traces of impurities, thus forming in the second part of the process the rich slag above mentioned, which it is intended to retain in the furnace for the purpose of coating the lining. The metal is tapped off when finished without allowing the slag to run out, and the slag is further enriched and thickened by lime and metallic oxid additions and the furnace tilted repeatedly as above described in order to coat the enriched and thickened slag on the bottom and sides of the furnace lining ready for the next charge of molten pig iron, which is then poured in and a reaction commences which removes the bulk of the impurities, this bringing us to the point which the description of this process started." (1,198,827, Sept. 19, 1916.)

Process of Breaking Steel Bars.—A novel process of breaking steel bars is patented by PIERRE V. L. BEL-LANGER of Paris, France. At the point in the bar where it is to be broken the bar is heated with an oxidizing blow-pipe flame. The metal becomes brittle at that point and, the bar being placed between two supports, is broken by pressure or blow on the opposite side to which the heating has been done. A flame temperature of about 700 deg. C. is used. It is claimed that the breaking of steel bars can be easily and quickly accomplished by this method. (1,201,137, Oct. 10, 1916.)

Reversing Regenerator-Furnaces.—A flue and valve arrangement for reversing regenerator furnaces is patented by LUTHER L. KNOX, of Avalon, Pa. (assigned to the Knox Pressed and Welded Steel Company of Pittsburgh, Pa.). The claim is as follows: "In a flue and valve arrangement for regenerative furnaces, the combination of air and gas regenerators, a stack flue running transversely of the regenerators, a continuous port connecting each of the regenerators with said stack flue, said ports being at the same level as the stack flue and all opening directly into the same side of said flue, each port having an admission valve in its upper wall, and each port also having a vertically movable damper between said valve and the stack flue; substantially as described." (1,203,748, Nov. 7, 1916.)

Welding Compound.—A compound to be used for welding iron and steel is patented by CHARLES W. PHELPS of Coupeville, Wash. The compound consists of nine parts pulverized "volcanic ash" and one part common salt. The metals to be welded are heated to cherry red, coated with the compound and the metals heated to a white heat, when hammering is applied. (1,199,020, Sept. 19, 1916.)

Tool-Steel Alloys.—RICHARD H. PATCH and RAD-CLIFFE FURNISS, of the Midvale Steel Company, patent a non-deforming tool-steel particularly adapted for dies, taps, reamers, and cutting tools for lathes and planers; it contains 79 per cent steel, 19.5 per cent chromium, and 1.35 per cent carbon. (1,206,902, Dec. 5, 1916.)

A partial substitution of cobalt for tungsten with very beneficial effects in tungsten-chrome steels is the predominating feature of another patent of the same inventors. A preferred composition is chromium 4 per cent, tungsten 13.5, vanadium 1.5, cobalt 15, iron 65, carbon 0.65. (1,206,834, Dec. 5, 1916.)

A third patent of the same inventors refers to the fact that by the addition to steel containing less than 1 per cent of carbon, of certain proportions of molybdenum, chromium and cobalt, the alloy becomes easier to forge, and less subject to sudden inexplicable physical effects; it also performs much more uniformly as cutting tool than do the known molybdenum tool steels. A typical composition is 4.0 per cent chromium, 8.0 molybdenum, 1.5 vanadium, 5.0 cobalt. (1,206,833, Dec. 5, 1916.)

Preparing Iron for Castings.—A patent of WILLIAM G. KRANZ, of the National Malleable Castings Company, relates to the treatment of iron intended to be made into castings, so as to overcome the difficulties resulting from the presence of relatively high carbon, manganese and silicon. The process is well indicated by the fourth claim which reads as follows: "The process of preparing iron for castings which consists in melting iron in a melting furnace, tapping a portion of such molten iron from said furnace and substantially removing its carbon in a Bessemer converter, adding said molten decarbonized metal to a larger portion of the molten iron from said melting furnace whereby the carbon in the combined charge is reduced and equalized, but remains above 1.50 of carbon, and finally treating the combined charge in a refining furnace without further substantial reduction of carbon." (1,206,861, Dec. 5, 1916.)

Manufacture of Iron and Steel.—A process of controlling the carbon content of iron and steel is patented by BRUCE FORD of Philadelphia, Pa. The process consists in supercarburizing molten iron in a Bessemer converter by alternately passing through the iron a hydrocarbon gas and air through separate valves. This carburized iron is then added to decarburized iron in another converter and the final product is obtained. The ultimate carbon content is determined by the amount of supercarburized iron added. As this latter iron has practically always the same carbon content, no chemical analysis is stated to be necessary. (1,205,611, Nov. 21, 1916.)

Titanium

Titanic Oxide.—LOUIS E. BARTON of Niagara Falls has patented a method of obtaining titanic oxide from ilmenite ores. The patent, which is assigned to the Titanium Alloy Manufacturing Company of Niagara Falls, relates to methods described in previous patents Nos. 1,106,409 and 1,106,410, dated Aug. 11, 1914, and No. 1,171,542, dated Feb. 15, 1916, granted to Mr. Barton and AUGUSTE J. ROSSI. These previous patents refer to a process in which the ilmenite ores were melted with an alkali sulphide, followed by lixiviation with water. The mixture was then heated in a bath of dilute sulphuric or hydrochloric acid, which dissolved out everything but the titanic oxide. The objection to the process was the production of hydrogen sulphide from the acid and ferrous sulphide. The present patent proposes to avoid this by the use of chlorine in lixiviation instead of acids. (1,201,541, Oct. 17, 1916.)

Electric Furnaces

Electric-Furnace Control Apparatus.—Apparatus for controlling electric furnaces, particularly arc furnaces, by connecting the electrodes or electrodes with a mechanism actuated by an electric motor is patented by JOHN A. SEEDE of Schenectady, N. Y., assigned to the General Electric Company. The motor is controlled through relays by a circuit-closing magnet responsive to variations of power in the furnace circuit. A switch is also provided for automatically disconnecting the control apparatus, thereby stopping the motor, when the voltage of the furnace supply current falls below the value to which the apparatus is adjusted. (1,206,603, Nov. 28, 1916.)

Hydrometallurgy

Wet Ore Extraction Process.—CHARLES S. BRADLEY of New York has patented an extraction process which is described especially in connection with copper ores containing iron and aluminium which it is desired to eliminate. The finely divided ore is first heated and the dust and fumes passed into an absorber. Both the roasted ore and the products from the dust and fumes absorber are then conveyed to a solution drum where the sulphates are converted into chlorides by the action of calcium chloride solution. The solution is then filtered to remove the gangue material and treated in another drum with calcium carbonate, which precipitates the high valency copper compounds (cupric chloride) and the iron and aluminium. The solution is filtered and the filtrate containing cuprous chloride and zinc chloride is treated with calcium oxide to recover the copper and zinc. The precipitates of cupric, iron and aluminium compounds are returned to the process ahead of the solution apparatus in order to furnish enough iron to insure all of the copper being extracted from the ore, as the iron will not go into solution until all the copper is dissolved. A further object of returning the high valency compounds is that they unite readily with sulphuric and sulphurous acids and form a certain amount of cuprous copper, thus making the process a cyclic one with continual withdrawal of cuprous solution. (1,204,932, Nov. 14, 1916.)

Oxygen Manufacturing Company Expanding Its Operations

The great increase in the demand for oxygen and acetylene gases for welding and cutting is manifested in the rapid growth of the latest company in this field. The Air Reduction Company, which was organized early in 1916 for the manufacture of oxygen and nitrogen from the air by the Claude process, now has nine plants in operation and contemplates putting a new one in operation every five weeks. A short account of the company was given in our issue of June 15, 1916, page 715. The Claude process is used by the American Cyanamid Company in Canada, and was described in our Vol. XIII, pages 187 and 312 (1913).

The company had at the start a contract with L'Air Liquide Société de Paris for rights to the Claude process for the manufacture of oxygen and nitrogen from the air. Complete equipment for four plants was to have been furnished with the contract to the American company, but the French Government took three of them because of the need of their products for war purposes. As soon as this situation became known to President Birge of the Air Reduction Company, he obtained control of the Superior Oxygen Company, which was using a somewhat similar process.

The principal plants are in Brooklyn, Chicago, Phila-

delphia, Buffalo, Pittsburgh, Defiance and St. Louis. Other plants or warehouses of the company are in the Bronx, New York City, Jersey City, Passaic, Paterson, Chicago Heights, Davenport, Grand Rapids, Joliet, Milwaukee, Peoria, Fort Wayne, Louisville, Toledo, Dayton, Baltimore, Boston, Detroit and Cleveland. The largest Claude oxygen plant in America is in Philadelphia. The company has also taken over one of the largest companies engaged in the production of acetylene, so that it will be able to furnish both the oxygen and the acetylene gases, together with a full line of equipment such as cutting and welding torches. Further, the company has made plans for the production of calcium carbide on a large scale, and for the production of several distinct lines of nitrogenous products both for use as fertilizer and chemical work. One of the most recent efforts of the company has been an educational campaign for demonstrating the uses of the oxy-acetylene torch in trade schools, manual training schools and technical institutes.

The capital stock of the company has been increased from \$4,500,000 to \$12,000,000.

An Apparatus for Locating Thermal Transformation Points

The more stringent requirements of designers of automobiles, aeroplanes and other machinery have caused more attention to be given to the proper heat treatment of steel and other metals. The strength, hardness, ductility and toughness of steel depend almost as much upon the temperatures at which it is worked, hardened, annealed and tempered as upon its chemical composition. Unless the temperatures are known accurately and with certainty, these qualities cannot be depended upon.

An apparatus for locating critical, recalcence and decalcence points, embodying the approved neutral-body method has been developed by the Leeds & Northrup Company, of Philadelphia, Pa. The method consists essentially in heating a small sample of the metal in contact with a larger neutral body and simultaneously measuring the temperature of the sample by a thermocouple and the temperature difference between the sample and the neutral body by a difference thermocouple while the furnace is being slowly heated and cooled. The apparatus plots these two quantities as co-ordinates upon a rectangular chart and the temperatures at which the various transformations occur are easily indicated in an unmistakable manner by rapid increases in the temperature difference between the sample and the neutral body. For example, at the A_c point, due to the solution of carbon on heating, the temperature of the sample lags markedly behind that of the neutral body.

The thermocouple used for measuring the difference between sample temperature and neutral body temperature is composed of two pieces of platinum joined by a short piece of platinum-iridium alloy. One of the junctions of the couple is in contact with the sample and the other in contact with the neutral body. The platinum-iridium couple develops a high electromotive force, which changes with temperature at a nearly uniform rate and is therefore well adapted for the purpose.

For indicating the changes in the electromotive force due to these transient differences in temperature between sample and sample holder a sensitive reflecting galvanometer is employed.

For measuring the temperature of the sample a platinum, platinum-rhodium thermocouple is employed in connection with a potentiometer.

In order to eliminate the labor and the possibilities

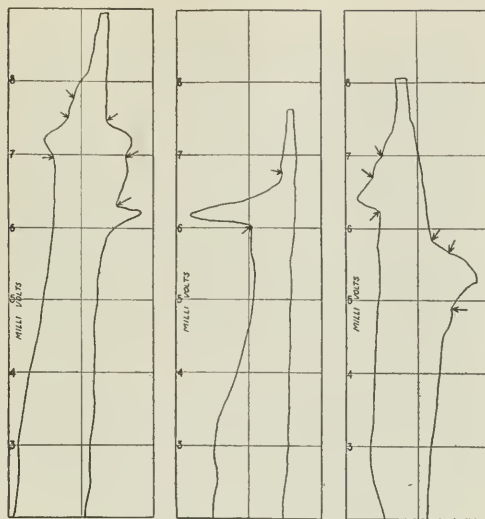


FIG. 1—TRANSFORMATION POINT CURVES FOR LOW-CARBON CHROME VANADIUM STEEL, (LEFT), HIGH-CARBON NICKEL STEEL, (CENTER), AND LOW-CARBON NICKEL STEEL (RIGHT)

of error involved in reading off the temperatures and temperature difference simultaneously from two different instruments, noting down the figures and subsequently constructing a curve, a transformation point indicator, which constructs its own graphical chart has been developed.

The paper upon which the chart is to be made is mounted upon a drum, which also carries the potentiometer slide wire. Bearing upon this drum is a pen. As the drum is revolved to keep the potentiometer in balance, the pen automatically records the corresponding electromotive forces, or temperatures, upon the paper.

The pen, together with a semi-transparent target, is mounted upon a carriage and this carriage can be made to travel parallel to the axis of the drum by rotating a worm shaft. The operator making the curve moves this carriage in such a way as to keep the spotlight from the galvanometer connected to the difference couple always on the semi-transparent target. By so doing the pen is caused to move back or forth across the record whenever the difference in temperature between sample and neutral body changes.

Representative transformation point curves obtained with the apparatus are shown in Fig. 1.

Opening of Bureau of Mines Building in Washington.—Invitations were issued to 1500 mining and metallurgical men of the Northwest to attend a smoker at the Bureau of Mines Building on the campus of the University of Washington, Jan. 12. The smoker marked the formal opening of the Federal mining and metallurgical experiment station in this building. Dorsey A. Lyon, head of the station, spoke on "The Purpose of the Station," and Robert F. McElvenny, superintendent of the Tacoma smelter, spoke on "The Metallurgical Situation in the Northwest." Music, boxing, wrestling and Japanese fencing were provided for the amusement of the gathering and a most enjoyable time was had.

A Device for Automatically Testing Liquids

A device for testing liquids continuously and automatically has been developed and patented by Walter C. Raddant of Elia, Cuba. It is being used successfully in testing for sugar in boiler feed water. A sectional view of the apparatus is shown in Fig. 1. The glass tube with graduations shown at the left in the center of the two larger tubes is used as a mixing tube. The larger outlet at the top of this tube is an inlet pipe, and the smaller one a vent pipe. The container at the left is used for holding an indicator and the container at the right holds acid. The containers and the mixing tubes have spring valves, the containers emptying into the mixing tube and the mixing tube having a bottom outlet. The electrically operated device at the right, consisting of a clock and electromagnet, actuates the cords connected to the plug cocks of the containers and mixing tube.

In operation the liquid to be tested is supplied to the mixing tube. At a predetermined moment the minute hand will make contact with the first screw. This energizes the right-hand electromagnet, exerting a pull on the cable and the opening valve of the container on the

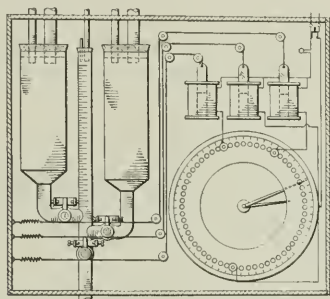


FIG. 1.—VERTICAL SECTIONAL VIEW SHOWING ARRANGEMENT OF PARTS OF LIQUID TESTING DEVICE

left. This permits some of the chemical indicator to flow from the container to the mixing chamber. After a predetermined interval of time has elapsed the hand reaches the next contact screw, where the foregoing operation is repeated and the container on the right opens. When the hand reaches the third contact screw the operation is again repeated, the bottom valve opening. It is pointed out that the valves only remain open while the minute hand is in contact with the screws, the valves immediately closing by virtue of their respective retractile springs. However, the bottom valve remains open a sufficient time to permit all of the contents of the tube to flow through the outlet and permitting some of the incoming liquid to wash the tube before the valve closes.

It would seem possible to apply the idea to any number of containers and mixing tubes, provided the action of the plug cocks could be made positive enough to give the desired proportions of reagents.

Society of Glass Technology Formed in England.—At a meeting held at Sheffield University on November 9th a society was formed to represent the glass manufacturing interests and to be known as the Society of Glass Technology. It will be a national society and will hold meetings at various places. Mr. W. F. J. Wood was elected President for the coming year, and Dr. W. E. S. Turner, of the University, Sheffield, secretary.

Personal

Mr. J. R. Baylis has been appointed bacteriologist of the Montebello filtration plant, of Baltimore. He was formerly chemist and manager of the Jackson, Miss., waterworks and filtration plant.

Mr. George M. Berry, president of the Syracuse Section of the American Chemical Society and chief chemist of the Halcomb Steel Company, Syracuse, N. Y., since its organization in 1905, has been secured by Syracuse University to give a special course of lectures on metallurgy in the College of Applied Science. These lectures will cover the metallurgy of the non-ferrous metals and that of iron and steel.

Mr. Felix Dreyfus, vice-president of Herman & Herman, Inc., manufacturers and dealers in coal tar products and intermediates, sailed for Genoa on Jan. 23, to visit the company's branches in Europe.

Mr. Andrew M. Fairlie has accepted an appointment as chemical engineer with the reorganized Tennessee Copper and Chemical Corporation, whose works are at Copperhill, Tenn.

Mr. Wm. H. Gaines is operating an electrolytic zinc plant for the Basin Salvage Co., Basin, Mont. The work is at present in the experimental stage, and several new ideas are being tried out.

Mr. Carl M. Hansen, widely known through his activities in connection with accident prevention, compensation and casualty insurance, as chairman of the Committee for Accident Prevention and Workmen's Compensation of the National Association of Manufacturers. Mr. Hansen, who is the author of "Universal Safety Standards," a work of thirteen volumes, has been a frequent contributor to technical journals on subjects relating to compensation, prevention and occupational diseases, as well as related subjects. He is a member of the American Society for Mechanical Engineers, American Statistical Society, Casualty, Actuarial and Statistical Society of America, and several other scientific bodies. He was born in Denmark and received his early training in that country and Germany. Coming to America in 1903, at the age of twenty-three, he entered the construction department of the Dominion Iron & Steel Company, Sydney, Cape Breton, going from there to Newfoundland as mechanical engineer for a Newfoundland mine operating syndicate; thereafter he was associated with the Atlas Engine Works at Indianapolis, Ind. On account of his interest in methods of handling work accidents in this country and in Europe, he devoted special study to this subject and became successively connected with several casualty insurance companies.

Professor D. D. Jackson has been designated acting head of the Department of Chemical Engineering, Columbia University, to serve in place of Professor M. C. Whitaker, absent on leave.

Mr. K. L. Kithil, formerly connected with the Bureau of Mines, is now general manager of the Schlesinger Radium Co., of Denver, Col.

Mr. P. M. McHugh, general sales manager of the Dorr Company, has left Denver for a three weeks' vacation. After spending three or four days in St. Louis on business, Mr. McHugh will spend the rest of his furlough in the South.

Mr. W. H. McKenna, vice-president of the Vanadium Alloys Steel Company, Pittsburgh, Pa., accompanied by Mrs. McKenna, has started on an extensive pleasure tour of Japan and China.

Mr. S. M. Marshall has severed his connection with the Southwark Foundry & Machine Company, of Philadelphia, to accept a position with C. P. Perin & Co., consulting engineers, 3 Rector Street, New York.

Professor F. J. Metzger of the Department of Chemical Engineering, Columbia University, has resigned his position to accept the position of manager of chemical development with the Air Reduction Company, 120 Broadway, New York. Professor Metzger will assume his new duties Feb. 1.

Mr. O. C. Ralston of the Utah section of the Bureau of Mines recently passed through Denver on his return to Salt Lake City.

Mr. C. J. Ramsburg, vice-president of H. Koppers Company, at a joint meeting of the Franklin Institute and the Philadelphia Section of the American Society of Mechanical Engineers, Feb. 6, will read a paper entitled "By-Product Coke and Coking Operations." The paper will be illustrated by lantern slides and a moving picture film showing the operation of a by-product coke plant.

Mr. Dudhy Shaw is now engineer with the Air Reduction Company, 120 Broadway, New York. Mr. Shaw was formerly engineer for the Davis Bournonville Co., but left them to design and install a complete hydrogenating and compound plant. This plant was duly constructed in Austin, Tex., under the name of the Walker Refining Co., and though small was very complete, using Diesel engines for prime movers, and with direct connected generators furnishing current for the electrolytic oxygen and hydrogen cells.

Mr. R. K. Stockwell, who has been chief engineer and superintendent of construction for the Braden Copper Company at Raucaque, Chile, for the past five years, will open a Western engineering and sales office of the Robins Conveying Belt Company in Salt Lake City, Utah.

Dr. John E. Teeple, consulting chemical engineer, New York City, has been appointed associate in chemical engineering, Columbia University, and will at once assume charge of the courses in chemical works management, advanced industrial chemistry and chemical engineering.

Obituary

William Ainsworth, prominent manufacturer of precision instruments, died at his home in Denver on January 1, after a sudden attack of pneumonia, at the age of 67. Mr. Ainsworth has been a resident of Denver since 1877 and was well known in the chemical and metallurgical circles all over the country. The analytical and assaying balances of his design rank among the best used in the arts.

Mr. Archibald Colville, chairman of the directors of David Colville & Sons, Ltd., large English iron and steel manufacturers, died at The Moorings, Motherwell, on Dec. 11, 1916.

Book Reviews

Diseases of Occupation and Vocational Hygiene. Edited by George L. Cober, LL.D. and M.D., and Wm. C. Hansen, M.D. 918 pages. Price \$8.00. Publishers, P. Blakiston's Son & Company.

The intelligent study and prevention of occupation diseases has received a great help and support in this voluminous work. The authors have covered the field completely and have, besides, included a copious number of references. It is a volume which should be placed in every works manager's library, be it a chemical industry or any other industry. The book is one that is well needed to-day in the modern tendency of protecting employees against conditions by which their health and future happiness are impaired.

The Engineer in War. By P. B. Bond. 187 pages. McGraw-Hill Book Company, Inc.

With the strong interest taken to-day by laymen in all walks of life in military matters, this book should offer an interesting, as well as valuable source of knowledge. It is as non-technical as an extremely technical subject can be, and with its extensive glossary of military terms and its interesting and excellent illustrations, will furnish every engineer and non-engineer interested in military engineering, an excellent fount of information.

The Physico-Chemical Properties of Steel. By C. A. Edwards, D.Sc. Octavo (15 x 22 cm.), 229 pages, 181 illustrations. Price \$3.50. London: Charles Griffin & Co., Ltd.; Philadelphia: J. B. Lippincott Company.

The author is professor of metallurgy in Sheffield University. The book is a mixture of good and indifferent. The preface speaks of very complete references being given, but the book in detail does not bear this out; e.g. Burgess' work on the critical points of iron, done at the U. S. Bureau of Standards, is not mentioned. There are three lines about the electrical resistance of iron, and no data given. But solidification of ingots, deformation and strain in working, slip-bands, and chemical and physical constitution are handled in a masterly way. It is a book for the specialist, but not entirely uniform in treatment or up to date—for which latter item present disturbed conditions in scientific literature may be some excuse. **Elementos de Electroquímica.** By V. de Vivaldi-Coaracy. 12 x 19 cm., 218 pages. Official publication of the Electrotechnical Engineering School of Porto Alegre, Brazil.

Professor Coaracy is known in South America for his brochure on Technical Instruction in the United States. In this small book he discusses very clearly the fundamental principles of electrolysis, the theory of electric batteries and accumulators. For Brazilian students reading only Portuguese this will be a welcome book, opening to them the gateway to further studies in electrochemistry.

CURRENT MARKET REPORTS

The Iron and Steel Market

What has occurred marketwise in the past fortnight has been a development in thought rather than in action. Buyers are not conducting themselves differently than formerly. They are very reserved, in the case of both pig iron and finished steel products, about making any commitments beyond the middle of the year, while they show at least as much insistence as formerly with respect to earlier deliveries, continuing to exert pressure upon the producers to make deliveries, in case they have already bought, or seeking fresh tonnages when they have not.

On the whole it is a quiet market in pig iron and steel, as it has been since the middle or fore part of December. Such quietness is always to be expected at the holiday period, but is hardly to be expected during the second half of January. The development in thought during the past two or three weeks has been along the line that the steel mills are not likely to be under pressure indefinitely, but rather that the amount of business already booked comes close to being a measure of trade prospects in general.

The possibility of an early termination of the European war, entertained for several weeks after the German suggestion of Dec. 12, having disappeared, the trade has been able to proceed upon the assumption that

the war is to end either late this year or at some later time and in the minds of many this reduction in the uncertainty has tended to clear the prospect immensely, on account of the coincidence that granted an indefinite continuance of the war these observers expect the pressure upon the steel industry to decrease toward the end of this year. The argument in favor of this view is that on account of the ocean shipping situation iron and steel exports must decrease while eventually domestic consumption will be restricted by the high prices, and meanwhile the productive capacity is being increased. This view is held by many buyers if not the great majority. Its correctness is not admitted by all sellers or even a majority. It is admitted that exports are likely to decrease but the suggestion is made that the decrease will be brought about by increased pressure at home for steel. Undoubtedly that is the correct analysis for the next few months, for steel is growing still scarcer, but there is no great warrant for a belief that domestic requirements for steel will be greater in the second half of this year than in the first half.

EXPORTS

Iron and steel exports increased almost continuously until September, 1916, when the total exports reported by weight amounted to 643,767 gross tons, comparing with 307,656 tons as the best record before the war, made in May, 1912. In October there was a decrease of 5 per cent and in November a further decrease of 9 per cent. Since November the losses in merchant vessels through submarine and other war activity have been at a greater rate than formerly and there is no prospect of anything but continued further decreases in the amount of merchant shipping available. The intense activity at all shipyards does not suffice to make up for the losses. The export statistics as commonly quoted are not illuminating for the reason that they are statistics of declared values, not of quantities.

DOMESTIC DEMAND

The record of domestic consumption of steel during this movement has been full of surprises. It used to be considered that there was a "safe" level for steel prices, beyond which they could not advance without consumption being curtailed on account of the cost. Approximately speaking this level was reached at the end of 1915, and at that time the mills were sold up to about the middle of July, 1916. They have continued under great pressure for six and a half months longer, showing that the consumption was not noticeably retarded by the passing of the traditional. It does not follow, however, that there is no price level at which consumption would be curtailed sufficiently to make an impress upon the mill position. There is no means of ascertaining the average price of the steel now being shipped but there is one concrete fact that is suggestive. On July 1, 1916, the mills had on their books a tonnage of business, which if suitably distributed among the different finished products would have carried them to this present date, and prices at that time were on an average \$14 per net ton below present prices. Some of the business now being filled was booked prior to July 1 and some of it was booked later. It is still to be determined whether full consumption would continue were all consumers forced to pay present prices, and the common view among consumers is that it would not. It is to be observed that the amount of strictly "war steel" being shipped is not a large proportion of the total output. It is believed that after the war there will be certain fresh demands for steel, at the more moderate prices that will then prevail, and such a view cannot well be harmonized with an idea that present domestic consumption is to

continue indefinitely, during the war, at the present high rate, for if so the demand after the war would be still greater and steel prices ought to advance instead of decline. Such a suggestion may appear rather far fetched but it is worth while to look at the matter from this angle. If there is good reason, and there certainly is, to expect a good demand for steel after the war, it is absurd not to consider the restrictive influence that war prices must exert on some lines of consumption.

TRANSPORTATION

The industry is suffering still more severely from lack of full transportation facilities. Coke shipments from the Connellsville region are about 25 per cent less than the requirements of the blast furnaces tributary to the region. At some groups of furnaces one or more stacks are banked and the remainder pushed to capacity, while other producers slow down their operations. At many furnaces, indeed, there has not been enough coke with which to bank. The curtailment in pig iron production does not appear to have directly caused any decrease in steel output, nor has it affected the pig iron market, except to bring out some insistent inquiry for small lots of malleable and foundry iron for immediate shipment to consumers dependent upon western Pennsylvania, valley and lake front furnaces.

Shipments of steel, particularly in the Pittsburgh and valley districts, have been curtailed by a few per cent on account of the railroads being unable to move loaded cars freely. Car shortages are not so much in evidence. The strenuous efforts made by the railroads to move empty cars appear to have been more or less successful but trouble crops out in this new manner. Some mills which a month ago could not secure enough empties for loading are now confronted with the danger that if they load cars they will be charged demurrage because they are not taken away.

Prices have been practically stationary all along the line. Effective January 23 the Steel Corporation subsidiaries advanced their prices on shapes and plates by \$3 a ton, to 3.25c. for shapes and 3.75c. for plates, but all such quotations are practically nominal, being for "shipment at mill convenience." Buyers feel that they need not concern themselves with deliveries so far in the future that it would be convenient for mills to make them.

Non-Ferrous Metal Market

Thursday, Jan. 25—Copper is higher on account of a scarcity of supplies, and tin has advanced in an unsettled market. Lead is virtually unchanged but supplies are scarce, spelter is slightly higher but the market has been quiet. Antimony has been in good demand and is higher.

Copper.—The large producers have not been offering any copper for sale before the middle of the year and the market has been dull. The refinery of the American Smelting & Refining Company at Perth Amboy, N. J., has been closed for almost two weeks on account of a strike, which is understood to have been settled now. This strike and the freight congestion in various parts of the country have tended to shorten supplies somewhat. Electrolytic is quoted at 32.50 to 33.00 cents with Lake at 31.50.

Tin.—Cables from London have been held up and naturally the market here has been in more or less of a confused state. There has been a fairly good demand for prompt deliveries but sellers have been shy. Straits tin is now quoted at 45.50 cents, an advance of about 3 cents in the last two weeks. There is a scarcity of

Banca tin reported. Arrivals to date this month are 2650 tons.

Lead.—This market has been very dull, but supplies are scarce and the independents are asking up to 8.00 cents with the trust price unchanged at 7.50.

Spelter.—Spelter is about $\frac{1}{2}$ cent higher, but the market has been quiet. The difficulty of obtaining freight room is holding back export business. Producers have not shown any desire to push domestic sales and are banking on a larger export business to take care of the enormous production. The quotation for prompt shipment is 10.00 cents at New York.

Other Metals.—Antimony is in good demand and has jumped up 2 cents to 16.50. Aluminium is quoted at 56.00 to 60.00 cents, magnesium \$3.00 to \$3.50, electrolytic nickel at 50.00 cents, cadmium at \$1.50, quick-silver \$80.00, platinum \$90.00, cobalt \$1.50 and silver at 76 $\frac{1}{2}$ cents.

Chemical Market

Coal tar products attracted possibly more attention than any other branch of the industry during the past fortnight. There appear to be an important number of consumers who are anxious to cover and have been taking advantage of any possible loopholes in the market and closing whenever there was a possibility of a good buy.

Benzol has been subject to quite a persistent inquiry. A number of large consumers are in want of supplies and must have them for nearby deliveries. The general position has been a firm one for any delivery up to March. Beyond March, the position is rather uncertain, as new productions will reach the market at that time, making the general situation a peculiar one. During the two weeks spot business ranged from 56c. to 58c. with contracts over the year averaging 51c. to 52c. One large contract was placed by one of the coke companies on the basis of 44c. for deliveries over the year but it is generally admitted that only a favored buyer could work a price such as this. The stipulation was that the benzol was not to enter into the munition trade, as the selling company is German owned, and will not sell for other than dye manufacture.

The **toluol** situation has been firmer than the benzol one. For spot and nearby delivery it has not been possible to do better than \$1.75 to \$1.80 and on contract \$1.45 to \$1.50 is named. A large munition concern that lately purchased on a very low basis has endeavored to cover again at a price about approximately equal to that upon which their last purchases were made. At the moment of writing they have not been able to secure offers within 25c. of their bid.

Aniline oil has been another coal tar product that has firmed up considerably, principally due to the heavy export inquiry from England. The market has at times reached below the 20c. level but to-day there is but little likelihood of securing important amounts under 25c. Even with the higher market, selling prices allow of a very narrow margin of profit to makers considering the present price of benzol and acids.

In contrast the market for **phenol** has been weak and the leading makers have all lowered their asking rate with but little actual consuming inquiry noted.

In the intermediates, **H acid** (the amidonaphthol disulphonic acid 1:8:3:6) continues to attract much attention. There are about five producers, two of which make for their own consumption. The product is an extremely difficult one to make and complicated machinery is used. It is the intermediate for the production of **direct black**. Contracts are nominally quoted at \$2 per pound for long terms basis 80 per cent.

Of the pharmaceutical chemical salts, **beta naphthol benzoate** attracts much attention owing to the impor-

tant export inquiry. There are about five producers on a commercial scale. Spot prices range from \$17 to \$20.

Alpha-naphthylamine is attracting considerable attention and as the output is a restricted one well under control a number of interests in the trade are contemplating its manufacture.

A production of **benzoyl chloride** is announced. This is an important intermediate for the manufacture of **malachite green**. It is quoted at \$18 on spot and about \$16 on contract. **Benzyl** and **benzal chlorides** are being made by several producers, the first named selling at \$3 and the latter at \$5.00. **Carbonyl chloride** and, of course, **Michler's ketone** is now produced in this country in a small way.

As the Bayer patents covering **aspirin** will expire next month, an active preparation is being made openly to manufacture the product. Of course, there has been a production of **acetyl salicylic** for some time and sold in a quiet way, but there will probably be a dozen makers ready for business as soon as the Bayer patents run out. Supplies of **acetic anhydride** are scarce, however, and these new makers will be up against a raw material problem.

In heavy chemicals, the interval has been a rather quiet one. On the spot **soda ash** is perhaps five points lower than two weeks ago. Some business has passed but of course with such an enormous production as is noted at the moment business must pass. **Caustic soda** is easier, resale lots, perhaps, keeping the market down to a level to which there was no legitimate title. Makers are well sold up and the export movement is really tremendous. For contracts, makers hold out at about the same prices prevailing a fortnight ago.

Bichromate of soda has taken a sharp drop, despite the efforts of leading interests to maintain the market. This market has been practically in the hands of one firm for many years past but owing to new inducements held out by high prices and an increased production of chrome ore at home there are now seven producers. Three of these manufacture for their own use. **Bichromate of potash** remains quite steady.

Cyanides of domestic manufacture continue high with practically no supplies available, particularly the potassium base. Japanese offers continue persistent and doubt is expressed whether present values will hold indefinitely in face of these offers.

Chlorates are about unchanged and the new manufacturers of this product are seemingly marketing their output without forcing values downward. **Copper sulphate** has been in fair request and values have not undergone substantial change.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET JANUARY 25, 1917

Acetone, Drums	per cent.	100 lb.	22 $\frac{1}{2}$	23
Acid, acetic, 28 per cent.	100 lb.	3.25	3.50	
Acetic, 56 per cent.	100 lb.	7.00	7.10	
Acetic, glacial, 99 $\frac{3}{4}$ per cent	carboys.	10 lb.	22	22 $\frac{1}{2}$
Boric, crystals	10 lb.	11 $\frac{1}{2}$	12	
Citric, crystals	10 lb.	6.6	6.8	
Cydic, crystals, commercial, 18 deg.	10 lb.	0.14	0.13 $\frac{1}{2}$	
Hydrochloric, 20 deg.	10 lb.	0.13 $\frac{1}{2}$	0.12	
Hydrochloric, C. P. conc., 22 deg.	10 lb.	0.13 $\frac{1}{2}$	0.15	
Hydrofluoric, 30 per cent, in barrels	10 lb.	0.52	0.54	
Hydrofluoric, 44 per cent.	10 lb.	0.4	0.5	
Lactic, 22 per cent.	10 lb.	0.5	0.6 $\frac{1}{2}$	
Nitric, 36 deg.	10 lb.	0.4	0.4 $\frac{3}{4}$	
Nitric, 42 deg.	10 lb.	0.52	0.54	
Oxalic, crystals	10 lb.	43	45	
Phosphoric, 85 per cent.	10 lb.	30	32	
Picric	10 lb.	65	75	
Pyrogallol, resublimed	10 lb.	3.15	3.20	
Sulphuric, 66 deg., Brimstone	10 lb.	29.00	21.00	
Sulphuric, 66 deg.	10 lb.	25.00	26.00	
Sulphuric, oleum (Fuming), tank cars.	10 lb.	35.00	36.00	
Tannic, U. S. P. bulk	10 lb.	50	1.00	
Tartaric, crystals	10 lb.	65	66	
Alcohol, grain, 188 proof.	gal.	2.72	2.74	
Alcohol, Wood, 95 per cent.	gal.	1.00	1.02	
Alcohol, Denatured, 180 proof.	gal.	65	67	
Alum, ammonia lump	10 lb.	0.4	0.4 $\frac{1}{2}$	
Alum, chrome	10 lb.	22	23	
Alum, potash lump.	10 lb.	0.54	0.52	
Aluminum Sulphate, technical	10 lb.	0.1	0.2	

Aluminum Sulphate, iron free.....	lb.	.03½	.03½
Ammonia aqua, 26 deg. carboys.....	lb.	.05	.05½
Ammonia anhydrous.....	lb.	.26	.26
Ammonium carbonate.....	lb.	.12½	.13½
Ammonium nitrate.....	lb.	.14	.14½
Ammonium sulphate, domestic.....	lb.	.04½	.04½
Amyl acetate.....	gal.	4.00	4.25
Arsenic, white.....	lb.	.09½	.09½
Arsenic, red.....	lb.	.65	.70
Barium chloride.....	ton	90.00	95.00
Barium sulphate (Blanc Fixe) powder.....	lb.	.04	.04½
Barium nitrate.....	lb.	.12	.12½
Barium peroxide, basis 70 per cent.....	lb.	.27	.27
Bleaching powder, 35 per cent.....	lb.	.04	.04½
Borax, crystals, sacks.....	lb.	.08	.08
Bromine, crude.....	ton	28.00	28.50
Bromine, technical.....	lb.	1.40	1.45
Calcium acetate, crude.....	lb.	.03½	.03½
Calcium carbide.....	ton	55.00	57.00
Calcium chloride, 70-75 per cent, fused, lump.....	ton	22.50	23.00
Calcium sulphate.....	lb.	.01	.01½
Calcium phosphate precipitate.....	lb.	.30	.30
Carbon bisulphide.....	lb.	.08½	.04½
Carbon tetrachloride, drums.....	lb.	.15	.16
Caustic potash, 82-92 per cent.....	lb.	.84	.86
Caustic soda, 76 per cent.....	100 lb.	4.00	4.05
Chlorine, liquid.....	lb.	.15	.16
Coppers.....	100 lb.	11.00	12.00
Copper carbonate.....	lb.	.35	.37
Copper cyanide.....	lb.	.70	.72
Copper sulphate, 99 per cent, large crystals.....	lb.	.11½	.11½
Cream of tartar, crystals.....	lb.	.40	.41
Epsom salt, bags.....	100 lb.	1.80	1.90
Formaldehyde, 40 per cent.....	lb.	.12	.12½
Glauber's salt.....	100 lb.	.65	.72
Iodine, resublimed.....	lb.	.53	.53½
Glycerine, C.....	lb.	4.10	4.20
Iron oxide.....	lb.	.02½	.02½
Lead acetate, white crystals.....	lb.	.13½	.13½
Lead arsenate.....	lb.	.08½	.10
Lead nitrate.....	lb.	.16	.17
Litharge, American.....	lb.	.09½	.09½
Lithium carbonate.....	lb.	1.02	1.03
Manganese dioxide.....	lb.	.65	.70
Magnesium carbonate, technical.....	lb.	1.2½	1.3
Nickel salt, single.....	lb.	.14	.14
Nickel salt, double.....	lb.	.11	.11
Phosphorus, red.....	lb.	1.10	1.20
Phosphorus, yellow.....	lb.	.65	.65
Potassium bichromate.....	lb.	.39	.40
Potassium bromide, granular.....	lb.	1.30	1.35
Potassium carbonate calcined, 80-85 per cent.....	lb.	.30	.35
Potassium chlorate, crystals.....	lb.	.63	.64
Potassium cyanide, 95-99 per cent.....	lb.	2.30	2.40
Potassium iodide.....	lb.	3.45	3.45
Potassium muriate, 80-85 per cent basis of 80 per cent.....	ton	360.00	375.00
Potassium nitrate.....	lb.	.31	.32
Potassium permanganate.....	lb.	3.50	4.00
Potassium prussiate, red.....	lb.	2.50	2.75
Potassium prussiate, yellow.....	lb.	.88	.90
Potassium sulphate, 90-95 p.c. basis 90 p.c. ton.....	260.00	275.00	
Rochelle salts.....	lb.	.34	.34½
Sal ammoniac, gray gran.....	lb.	.08½	.10
Sal ammoniac, white gran.....	lb.	.16½	.17½
Salt soda.....	100 lb.	1.05	1.15
Salt cake.....	100 lb.	.70	.75
Silver cyanide, based on silver market.....	oz.	.72	.49½
Silver nitrate.....	oz.	14½	14½
Soda ash, 58 per cent, light, flat.....	lb.	2.80	2.90
Soda ash, 58 per cent, dense, flat.....	lb.	3.25	3.30
Sodium acetate.....	lb.	.08½	.09
Sodium benzoate.....	lb.	.85	.85
Sodium bicarbonate, domestic.....	100 lb.	1.65	1.70
Sodium bicarbonate, English.....	lb.	.02½	.03
Sodium bichromate.....	lb.	.16	.16½
Sodium bisulphite, powd.....	lb.	.04½	.04½
Sodium chloride.....	lb.	.25	.26
Sodium cyanide.....	lb.	1.60	1.65
Sodium fluoride, commercial.....	lb.	.12	.12
Sodium hyposulphite.....	lb.	.01½	.01½
Sodium nitrate, refined.....	lb.	3.27½	3.30
Sodium nitrite.....	lb.	.11½	.12½
Sodium peroxide.....	lb.	.90	.95
Sodium phosphate.....	lb.	.04½	.04½
Sodium prussiate, yellow.....	lb.	.84	.84
Sodium silicate, liquid, 60 deg.....	100 lb.	1.65	1.75
Sodium sulphide, 30 per cent crystals.....	lb.	.02	.02½
Strontium nitrate.....	lb.	.26	.28
Sulphur chloride, dry.....	lb.	.21½	.21½
Sulphur, flowers, sublimed.....	100 lb.	2.30	2.35
Sulphur, roll.....	100 lb.	1.95	2.00
Sulphur, crude.....	ton	35.00	38.00
Tin bichloride, 50 deg.....	lb.	.13½	.13½
Tin oxide.....	lb.	.46	.48
Zinc carbonate.....	lb.	.24	.26
Zinc chloride.....	lb.	.12½	.14½
Zinc cyanide.....	lb.	.20	.20
Zinc dust.....	lb.	.20	.25
Zinc oxide, American process XX.....	lb.	.11	.11½
Zinc sulphate.....	lb.	.06½	.06½

Coal Tar Products (Crude)

Benzol, pure, water white.....	gal.	.56½	.59
Benzol, 90 per cent.....	gal.	.55	.60
Toluol, pure, water white.....	gal.	1.75	1.80
Xylol, pure, water white.....	gal.	1.00	1.15
Solvent naphtha, water white.....	gal.	.21	.22
Solvent naphtha, crude heavy.....	gal.	.13	.18
Creosote oil, 25 per cent.....	gal.	.25	.27
Dip oil, 20 per cent.....	gal.	.25	.25
Pitch, various grades.....	ton	8.00	18.00
Carbolic acid, crude, 95-97 per cent.....	lb.	.85	.90
Carbolic acid, crude, 50 per cent.....	lb.	.80	.65
Carbolic acid, crude, 25 per cent.....	lb.	.84	.36
Cresol U. S. P.....	lb.	.18	.22

Intermediates, Etc.

Alpha naphthylamine.....	lb.	1.25	1.30
Aniline oil.....	lb.	.23	.24
Aniline salts.....	lb.	.27	.30
Anthracene, 80 per cent.....	lb.	.10	.10½
Benzidine, base.....	lb.	4.50	5.25
Benzoic acid.....	lb.	1.65	1.75
Beta Naphthol.....	lb.	8.50	8.50
Dimethylaniline.....	lb.	.80	.90
Diphenylamine.....	lb.	.60	.65
II-acid.....	lb.	.85	.90
Metaphenylenediamine.....	lb.	2.25	2.50
Monochlorobenzene.....	lb.	1.75	1.85
Naphthalene, flake.....	lb.	.32	.34
Naphthalene acid, crude.....	lb.	.09	.09½
Ortho-amidophenol.....	lb.	1.85	2.00
Ortho-toluidine.....	lb.	1.20	1.30
Para-amidophenol base.....	lb.	4.25	4.50
Para-amidophenol hydrochloride.....	lb.	6.00	6.25
Paranitraniline.....	lb.	1.40	1.50
Paraphenylenediamine.....	lb.	3.50	4.00
Para toluidine.....	lb.	1.60	1.70
Phenol U. S. P.....	lb.	.48	.50
Resorcin technical.....	lb.	9.00	9.25
Resorcin, pure.....	lb.	17.00	17.50
Salicylic acid.....	lb.	.90	1.00
Salol.....	lb.	1.90	2.00
Sulphanilic acid.....	lb.	.85	.86
Toluidine-mixture.....	lb.	.90	1.10

Petroleum Oils

CRUDE (AT THE WELLS)

Pennsylvania.....	bbbl.	3.05	—
Corning, Ohio.....	bbbl.	2.38	—
Somerset, Ky., 32 deg. and above.....	bbbl.	2.18	—
Waco, Ohio.....	gal.	2.00	—
Indiana.....	bbbl.	1.63	—
Illinois.....	bbbl.	1.82	—
Oklahoma and Kansas.....	bbbl.	1.70	—
Caddo, La., light.....	bbbl.	1.70	—
Corsicana, Tex., light.....	bbbl.	1.70	—
California, 14 to 17.9 deg.....	bbbl.	.73	—
25 to 25.9 deg.....	bbbl.	.82	—

LUBRICANTS

Black, reduced, 29 gravity, 25-30 cold test.....	gal.	13½	.14
Cylinder, light.....	lb.	.21	.26
Cylinder, dark.....	lb.	.18	.19
Extra cold.....	lb.	.26	.31
Paraffine high viscosity.....	lb.	.29½	.30
Paraffine, 903 spec. gr.....	lb.	.21½	.22
Paraffine, .865 spec. gr.....	lb.	.18½	.19

Flotation Oils

Pine oil, steam distilled.....	gal.	.59	—
Pine oil, destructively distilled.....	gal.	.47	—
Pine-tar oil.....	gal.	.19	—
Pine-tar oil, double refined.....	gal.	.30	—
Pine oil, light.....	gal.	.37	—
Pine oil, heavy.....	gal.	.37	—
Pine tar, thin.....	gal.	.18	—
Turpentine, crude.....	gal.	.38	—
Hardwood oil, f.o.b. Michigan.....	gal.	.16	—
Creosote, coal tar neutral.....	gal.	.15	—
Creosote, coal tar, acid.....	gal.	.21	—
Coal tar, thin.....	gal.	.12	—

Vegetable and Other Oils

China wood oil.....	gal.	.13	.13½
Cottonseed oil, crude.....	gal.	.83	—
Linseed oil, raw.....	gal.	.95	—
Peanut oil, crude.....	gal.	.85	.86
Rosin, 280 lb.....	bbbl.	6.30	—
Rosin oil, first run.....	gal.	.38	—
Rosin oil, fourth run.....	gal.	.70	—
Soya bean oil, Manchuria.....	gal.	.12	.12½
Turpentine, spirits.....	gal.	.55½	—

Miscellaneous Materials

Barytes, floated, white, foreign.....	ton	38.00	40.00
Barytes, floated, white, domestic.....	ton	25.00	35.00
Beeswax, white, pure.....	lb.	.43	.50
Carbamide waste.....	lb.	.85	—
Chalk, light, precipitated, English.....	lb.	.02½	.05½
Feldspar.....	ton	8.00	12.00
Fuller's earth, powdered.....	100 lb.	.80	1.05
Plaster of Paris.....	bbbl.	1.85	1.70
Red lead, dry, carloads.....	lb.	.09¾	—
Soapstone.....	ton	10.00	12.50
Talc, American, white.....	ton	10.00	13.00
White lead, dry.....	lb.	.08¾	—

Refractories, Etc.

(F.O.B. WORKS)

Chrome brick.....	net ton	120.00	130.00
Chrome cement.....	net ton	80.00	—
Clay brick, first quality fireclay.....	per 1000	40.00	50.00
Magnesite, Grecian, dead burned.....	net ton	55.00	90.00
Magnesia brick, Grecian, 9 x 4½ x 2½.....	net ton	135.00	140.00
Silica brick.....	per 1000	40.00	45.00

Ferroalloys

Ferro-carbon-titanium, carloads.....	lb.	.08	—
Ferromanganese.....	lb.	Nominal	—
Ferromanganese, domestic, delivered.....	ton	175.00	150.00
Ferromanganese, English, seaboard.....	ton	165.00	—
Ferromolybdenum.....	lb.	4.00	—
Ferrosilicon, 50 p.c. carloads, del. Pittsburgh ton.....	125.00	150.00	—
Ferrosilicon, 50 p.c. contract, del. Pittsburgh ton.....	100.00	—	—
Ferrotungsten, 75-85 p.c., f.o.b. Pittsburgh.....	lb.	1.95	—
Ferrovandium, f.o.b. works.....	gal.	2.75	3.00

INDUSTRIAL

Financial, Construction and Manufacturers' News

Financial

A syndicate composed of the principal banking and business interests of Norway has purchased the seven-eighths interest in the Arctic Coal Company, held by J. M. Longyear and Frederick Ayer, of Boston. The deal included some minor properties including ships, but the major properties are the famous Spitzbergen mines, located on the Spitzbergen islands in the Arctic that lie north of Norway and only about 700 miles from the North Pole. A new company has been formed with a capital of 10,000,000 crowns (\$2,650,000).

The Arctic Company's property covered about 170 square miles. Most of the work completed has been of a development nature and the output has not amounted to much more than 200,000 tons. Exploration showed many valuable and extensive veins of semi-bituminous coal, one alone disclosing 100,000,000 tons.

All Points Trading Company, Inc., New York. Capital \$5,000. Incorporated to manufacture drugs, medicines, paints, chemicals, oils, dyestuffs, by G. V. Sheridan, S. D. Muney and A. L. Berman, 56 West 110th Street.

The Alto Cotton Oil & Mfg. Company, Alto, Texas. Capital \$25,000. Incorporators: H. H. Berryman, J. E. Waters and T. Arant.

The American Abrasives Company, has been incorporated at Dover, Del., by E. G. Neiss Wayne, L. L. Voigt, George M. Harton, all of Pittsburgh.

The American Magnesium Corporation, Niagara Falls, N. Y. has been incorporated with a capital of \$200,000, in New York State. The charter states that the company is authorized to manufacture magnesium, barium, calcium and other metals. The directors are E. W. Burdick, L. J. Hallenbeck and J. J. Devereux, all of New York.

Aroostook Pulp & Paper Company, Boston, Mass. Capital \$500,000. Incorporators: A. N. Blandin, George S. Lewis, 141 Milk Street, and S. F. Johnson.

Bald Hill Mining Company, Seattle, Wash. Capital \$1,000,000. Incorporators: A. C. Smith, G. Mathew, L. Stadler, E. W. Winslow and B. T. Ulrich.

The Blackstone Oil and Paint Company, Cleveland, Ohio. Capital \$10,000. Incorporators: G. T. Baudouin, W. S. Scarus, J. E. Robinson, A. F. Gaughin and T. A. Gillespie.

Bristol Power, Pulp & Paper Company, Wilmington, Del. Capital \$1,000,000. Incorporated to manufacture wood pulp and paper, by K. M. Dougherty, M. C. Donohue and F. Giles, Wilmington, Del.

Burdett Oxygen Company, Chattanooga, Tenn. Capital \$100,000.

Columbia Bronze Corporation, Freeport, N. Y. Capital \$150,000. Incorporated as founders, welders, etc., by L. H. Rose, H. W. Bennett and J. A. Sutter, East Orange Parkways.

Congress Copper Company, Kittery, Me. Capital \$2,500,000. Incorporated to operate mines and mineral lands.

Connecticut Smelting & Foundry Corporation, Wilton, Conn. Capital \$300,000. Incorporated to conduct mills for the treating of metals.

Cornell Pulp Reduction Company, Inc., Watertown, N. Y. Capital \$50,000. Incorporated to deal in pulp, hardwood, fibrous products. Incorporators: W. N. Cornell, G. H. Burna and P. B. Hudson, Watertown.

Coeur d'Alene Federal Mines Corporation, Portland, Ore. Capital \$1,000,000. Incorporated to do mining business by B. E. Sanderson, E. V. Mann, Charles D. Booth, D. and L. Mfg. Company, New York. Capital \$10,000. To manufacture metal specialties. Incorporators: J. H. Miller, M. Dohrlik and M. Lansky, 2322 Crotona Avenue, Bronx.

H. T. Dakin Paper Company, Waterbury, Conn. Capital \$55,000. Incorporated to manufacture and deal in all kinds of paper, by R. Dumouchal, A. H. Anderson and R. S. Walker.

Delta Beet Sugar Corporation, New York. Capital \$200,000. Incorporated to manufacture sugar beets, sugar, by-products, by T. D. Adams, M. G. Laux and A. H. Curtis, 43 Exchange Place.

Diversey Foundry Company, Chicago, Ill. Capital \$10,000. Incorporators: Catherine M. Rowbottom, James J. Rowbottom.

Eastbrook Copper Company, Delaware. Capital \$100,000. Incorporated to do a general mining business by G. J. Powell, E. W. Stevens, Gwendolyn J. McNeil, all of New York.

The Electric Smelting Corporation, Baltimore, Md. Capital \$100,000. Incorporators are Attorney Adolph Schoenels, J. F. Dirzuweit and Katharine Dirzuweit, of Baltimore.

J. P. Eustis Mfg. Company, Cambridge, Mass. Capital \$103,000. Incorporated to deal in metals by J. P. Eustis, Newton, Mass. Treasurer, Frank Owen White, Brookline, Mass. clerk.

Fall Mountain Pad & Paper Company, Vermont. Capital \$10,000. Incorporators: F. L. Thompson, F. A. Moore, H. B. Underhill, Wellows Falls and J. W. King, Walpole, N. H.

Farbenfabriken of Elberfeld Company, Paterson, N. J. Capital \$125,000. Incorporated to manufacture chemicals, dyes, etc.

Flax Fiber Company, Helena, Mont. Capital \$50,000. Incorporated to engage in the manufacture of fiber. Incorporator: George Person and others.

Fritzsche & Kleason, Buffalo, N. Y. Capital \$10,000. Incorporated to a paint, dye and varnish business. Incorporators: H. L. Jauch and R. J. Kimball.

Globe Chemical Company, Broadway, Jersey City. Capital \$3,000. Incorporated to manufacture chemicals. Incorporators: H. W. F. Lorenz, A. Proven, J. F. W. Lorenz and L. J. Brown, Jersey City.

Good Faith Oil & Gas Co., Dover, Del. Capital \$240,000. Incorporators: Julia S. Jones, A. B. Blagoe, H. N. Fembelton, all of Dover.

Hattiesburg Pulp & Board Company, Fenwick, La. Capital \$125,000. Incorporated to manufacture wood and paper.

The Henle Wax Paper Mfg. Company, Inc. Capital \$50,000. Incorporated to manufacture paper, pulp, cloth and textile fabrics. Incorporators: R. Vallantine, A. Schmitt and C. O. Maas, 57 West 75th Street.

Hudson Bay Paint Company, Inc., Buffalo, N. Y. Capital \$25,000. Incorporated to manufacture paint and varnish, by G. Staumacher, 1616 Delaware Avenue: A. A. Hoestermann, 69 Moullier Street, and W. J. Lavery, 19 Kulline Street, Buffalo.

Ideal Acetylene Company, Inc., Delaware. Capital \$400,000. Incorporated to manufacture and sell acetylene and gas generators. Incorporators: H. E. Latter, N. P. Coffin, Wilmington, Del., and C. M. Igner, Elkton, Md.

Ideal Leather Company, Inc., New York. Capital \$10,000. Incorporated to manufacture leather and chemicals, by James V. Padula, G. Compatori, Newark, and Jos. Vicariat, Bellevue.

Imperial Chemical Corporation, New York. Capital \$750,000. Incorporated to manufacture coal tar products, explosives, etc., by H. S. Perrigo, 660 St. Nicholas Hanson, Place, New York City, and S. C. T. Dodd, 1918 Avenue H, Brooklyn.

Jersey Consolidated Copper & Gold Mining Company, Wilmington, Del. Incorporated to do mining business. Capital \$100,000.

K. & T. Chemical Corporation, New York. Capital \$35,000. Incorporated to manufacture chemicals, dyestuffs, oils, paints, etc., by W. B. Root, 1437 Sterling Place, Brooklyn: E. L. Karliner, 939 Simpson Street, New York City: F. J. Byrne, 529 Broadway, New York.

Keystone Leather Chemicals Company, Delaware. Capital \$25,000. Incorporated to manufacture chemicals and chemical compounds.

Langan Paint Company, Kewanee, Ill. Capital \$40,000. Incorporators Jas. M. Langan, C. A. Langan and Jas. F. Langan.

The Lehigh Valley Facing Company, Wilmington, Del. Capital \$100,000. Incorporated to manufacture foundry facings. Incorporated by K. M. Dougherty, M. C. Donohue and F. Giles, Wilmington, Del.

McAuliffe Paper Company, Inc., Burlington, Vt. Capital \$50,000. Incorporators: W. A. McAuliffe, Ottawa, E. L. and H. J. McAuliffe, of Burlington.

Maratino Coating Corporation, Wilmington, Del. Capital \$50,000. Incorporated to manufacture and deal in chemicals.

Matthews Steel Co., Newark, N. J. Capital \$50,000. Incorporated to deal in iron and steel by J. Swenson, J. S. Swenson and H. Todd, Newark.

Metasap Chemical Company, 10-20 Essex Street, Harrison, N. J. Incorporated to sell chemicals. Incorporators: J. Phillips, 25 Hillsale Avenue, Newark; R. Biehringer, 112 Second Avenue, Newark; W. E. Wachsman, 102 Lord Avenue, Bayonne, and C. P. Sulick, 313 Clifton Avenue, Newark.

Moore Paper Mills Corporation, Albany, New York. Capital \$50,000. Incorporated to manufacture paper and boxes. Board by William P. Moore, Charles G. and Blanche S. Moore, of Buffalo.

The Ohio Pattern, Works & Foundry Company, Cincinnati, Ohio. Capital \$200,000. Incorporators: Jos. E. Hausfeld, Amelia S. Hausfeld, Ed. E. Hausfeld, Victor E. Tresise, Grace L. Tresise and Fannie Pearl Tresise.

Outwear Leather Corporation, New York. Capital \$350,000. Incorporated to manufacture rubber articles, by M. T. Kelly, W. Phinney and G. H. Wyckoff, 115 Broadway.

Parsons Bar Company, Charlotte, N. C. Capital \$100,000. To deal in dyestuffs and chemicals. Incorporated by W. A. Parsons, E. B. Parsons and J. M. Barr, of Charlotte.

Patent Record Publishing Co., Inc., New York. Capital \$75,000. Incorporated to publish, print, deal in mail, paper, products, cloth, drugs, photographs, etc. (type apparatus) by H. L. Varian, E. H. Ball and W. D. Kemp, 459 Fifth Avenue.

The Pequotian Rock Valley Paper Company, Morristown, N. J. Capital \$140,000. Incorporated to carry on the manufacturing business at Butler, by Isabel C. White, Frank S. White, Walter C. White and Joseph C. White.

The Phillips Lead & Supply Co., Providence, R. I. Capital stock increased from \$30,000 to \$100,000.

Quick-Kleen Chemical Company, Inc., Brooklyn, N. Y. Capital \$5,000. Incorporated to manufacture soap, perfumery, oils, gases, chemicals. By C. H. Hoag, D. Deminger, J. A. Eadie, 505 De Kalb Avenue, Brooklyn, N. Y.

Royal Dye Works, Inc., New York. Capital \$10,000. Incorporated to dye furs, skins and to make goods. Incorporators: L. Scorsons, F. P. Kamholz and W. Koenig, 25 Echo Road, New Rochelle.

Sedalia-Lebanon-Novata Lead and Zinc Company, Novata, Ark. Capital \$100,000. Incorporated by A. C. High, 1000 N. C. Mayfield, Lebanon, Mo., and J. W. Palmer, Sedalia, Mo.

Seneca Copper Corporation, New York. Capital \$1,000,000. Incorporated to do mining, milling gold, silver, copper, etc., products and by-products, deal in agricultural products, drugs, furniture, machinery, supplies, etc., by F. C. Fischer, chemist, and K. A. Duffy, 15 Broad Street, New York City.

Sinclair Gulf Corp., Albany, N. Y. Capital \$5,000,000. Incorporated to carry on a mineral oil and gas business.

Tadaco Turpentine Co., Mobile, Ala. Capital \$5,000. Incorporated to engage in the general timber and turpentine business in south Alabama. Incorporators, T. J. Taylor, S. Lowenstein, A. Lowenstein, H. C. Taylor, R. E. Crum, J. W. Gray, D. Dumont and B. C. Fick.

Triangle Leather Goods Corp., New York. Capital \$5,000. Incorporated to manufacture leather novelties. Incorporators, M. Moskowitz, F. and J. Hart, 223 East 83rd Street.

Troy-Kalspell Mining Company, Troy, Idaho. Capital \$300,000. Incorporated to take over the 15 claims of Wood & Hogan, 12 miles west of Troy, in Idaho.

Umans Dye Works, Inc., New York. Capital \$16,000. Incorporators, E. London, R. and H. Umans, 215 W. 11th Street.

The United States Smelting & Refining Co. has purchased a controlling interest in the Big Four Exploration Company, which handles 800,000 daily of old mill dumps in Utah. The Big Four company's office is in Newhouse.

Universal Leather Company, Newark, N. J. Capital \$50,000. Incorporated to manufacture and deal in leather goods. Incorporated by Walter F. Gins, Stanleigh F. Friedman, New York; Charles B. Sutter and Meyer E. Ruback, Newark, N. J.

The Wisner Oil Company, Bartlesville, Tex. Capital increased from \$100,000 to \$200,000.

Wright Chemical Corporation, Newark, N. J. Capital \$100,000. Incorporated to manufacture chemicals, dyes, dyestuffs, acids, alkalies, salts and paints. Representative Allan E. Crocker 93 Park Row, New York.

Yellow Pine Paper Mill Co., Orange, Tex., has increased its capital from \$500,000 to \$1,000,000.

Construction and Operation

Arizona

BISBEE.—The new smelter of the United Verde Extension Company is expected to be ready in four months from the time work is actually commenced. Until this smelter is completed, the Extension Company will continue to market its ores at Douglas and Humboldt.

Arkansas

FORT SMITH.—The Fort Smith Smelter Company will build a \$350,000 lead and zinc smelting plant to contain 6,000 retorts.

California

JACKSON.—Messrs. Simmonds & Latham of Melones will build a \$15,000 cyanide plant near Jackson to work tailings of the Argonaut mine. There are about 200,000 tons of this material available. A flotation process may be installed later.

LONG BEACH.—Mr. Cyril E. Bratton, of Seattle, plans the erection of a \$150,000 plant at Long Beach for the manufacture of strontium nitrate. The proposed plant will be located just west of the California Glass Insulator Works near the Southern Pacific Main Line between Long Beach and San Pedro. It will be operated as a Bratton Manufacturing & Chemical Company.

LOS ANGELES.—The R. W. Pridham Paper Mill will make repairs and alterations costing \$50,000. The plant was recently damaged by fire.

SANTA BARBARA.—The news that a potash factory would be established at Summerland, near Ortega Hill, has aroused millionaire residents of exclusive Montecito. The opposition is based on the contention that the benefits to the community would be small in comparison with the objection of cutting the kelp which would leave the coast open to the full force of the storms, resulting in heavy damage.

Colorado

DELTA.—The Holly Sugar Company plans the erection of a \$1,500,000 factory at Delta, Colorado and also plans to purchase another factory at Grand Junction, tremendously increasing its beet sugar output.

DENVER.—The Stearns-Roger Manufacturing Company has been awarded the contract for the construction of a \$1,500,000 beet sugar factory to be erected at Delta, Utah.

Connecticut

FAIRFIELD.—The Hamilton & De Loss Company, recently organized, with \$300,000 capital, has secured a site for a factory near the Handy & Harmon plant and plans the erection of a \$100,000 structure. The company will manufacture metal parts and will use scrap silver, steel, brass and copper, and expects to employ from 500 to 800 hands. H. H. Hamilton, President of the Whiting Manufacturing Company, is president of the new company, and H. H. De Loss, president of the Handy & Harmon Company, is also interested.

HARTFORD.—The Russell Company is erecting a new dye house, 34 x 80 feet, two stories high.

MERIDEN.—The Quanguo Cut Glass Company, of Hawley, Pa., has purchased the entire equipment from the glass plant of Hall & Callahan in this city and will ship it to Hawley.

NEW HAVEN.—The Pennsylvania Seaboard Steel Corporation will erect a one-story steel structure to cost about \$25,000. The contract has been let to the Belmont Iron Works of New York.

STAMFORD.—The Stamford Rolling Mills Company has awarded to the Austin Company the contract for a new building to be used for smelting.

District of Columbia

WASHINGTON.—The Department of Agriculture has perfected a citrus fruit peeling machine and developed processes for pressing and chemically treating the removed peel whereby they believe an oil equal in quality to the imported oil may be produced at a cost to enable competition with the foreign product. The new process aims to make use of low-grade oranges heretofore wasted.

Florida

PENSACOLA.—The Pensacola Fertilizer and Oil Company, with headquarters at 21 Spruce Street, New York City, will con-

struct an oil and fertilizer plant on a 90-acre site at Grassyview. Actual work will be started in February. The capacity of the plant will be about 100 tons of fish scrap per day and about 200 barrels of oil.

Illinois

ROCK ISLAND.—The paint factory of the Illinois Oil Company was expected to be completed during the latter part of January. The factory will be used for the mixing of oils and pigments in the process of manufacture of paint. The building when completed will cost \$50,000. Mr. P. P. Welch is president of the company.

Indiana

TERRE HAUTE.—The Grasselli Chemical Company is now building a large chemical and zinc smelting plant in the north of the city, which will be completed by the first of 1918. It will represent an investment of \$3,000,000 and one large building will be 250 x 300 feet. Actual work will be started about the middle of the coming spring.

TERRE HAUTE.—The Root Glass Company will rebuild the factory which was destroyed by fire in December.

Iowa

CEDAR RAPIDS.—The Holland Furnace Company has completed negotiations with the Chamber of Commerce of Cedar Rapids, Ia., and will erect a new factory in that city.

DUBUGUE.—The Adams Company will erect a large addition to its plant on Fourth Street during the coming year. The new building will house the machine shop. The company operates a foundry and manufactures hardware specialties and machinery.

Kansas

ELDORADO.—A new \$300,000 refinery is planned by the Midland Refinery Company, which has recently been chartered by V. G. Skully, of Tulsa, Okla., and W. Irving Osborne, of Chicago.

Kentucky

IRVINE.—The Cumberland Torpedo Company announces the establishment of a factory at Miller's Creek for making nitroglycerin to be used in shooting oil wells.

Maine

BANGOR.—The Texas Oil Company has purchased from I. M. Pierce and W. A. Finnigan a parcel of land on the Penobscot River on which tanks and building will be erected for making Bangor the distributing and commercial center of eastern and northern Maine.

GARDNER.—Major Lamb has received a letter from a large Western company making inquiries regarding location for a sulphite pulp mill and asking for assistance from the city.

Maryland

BALTIMORE.—The Electric Smelting Corporation, a new company formed with a capital of \$100,000, will undertake the manufacture of electric furnaces for melting copper, brass and other nonferrous metals, and for manufacturing alloys. The incorporators are Adolph Schoenels, John F. Dirzuweit and Katharina Dirzuweit, all of Baltimore.

Michigan

MUSKEGON.—The Lakey Foundry Company will erect a large modern foundry plant which will more than double its present output. The present foundry produces about 40 tons of castings per day. It is planned to have the new structure completed by July 1.

Montana

BIGFORD.—Glacier Park Pulp & Paper Co. will erect paper mill in this vicinity, and for this purpose company has been organized at St. Paul with \$100,000 capital. S. S. Gillette, pres., 327 Nicollet Ave., Minneapolis.

Nevada

ELY.—The Consolidated Copper Mines Company will build another 500-ton unit at its Giroux mill. The first 500-ton section will be placed in commission about January 15.

New Jersey

CAMDEN.—Fire caused \$50,000 damage to the plant of the General Chemical Company on Cooper River. The pottery, office, laboratory and pottery storehouse were destroyed.

HARRISON.—Plans prepared for erection of addition at rear of Crucible Steel

Co. plant between Sixth and Seventh Sts.; cost about \$200,000.

JERSEY CITY.—The Globe Chemical Company, 163 Broadway, Jersey City, a new company capitalized at \$300,000, will increase its production of benzoic acid to 100 lbs. per day. Dr. Henry W. Lorenz is superintendent of the plant.

KEARNY.—General contract awarded by Egyptian Lacquer Mfg. Co. to Turner Construction Co., 11 Broadway, New York, for erecting on this building, 2-story, 160 x 92 ft., with L 30 x 40 ft.; one 2-story, 120 x 60 ft., office building; 1-story, 60 x 60 ft., and railroad trestle.

LINDEN.—The Ammo-Phos Chemical Corporation's new plant will cost \$200,000 and the Grasselli Chemical Company's factory additions will cost \$55,000.

NEWARK.—The North American Copper Company, 52 Vanderbilt Avenue, New York City, will erect a large copper refining plant on the Kearny meadows between the Hackensack River and Hackensack Avenue.

NEWARK.—The plant of Seaboard By-Products Coke Company is progressing nicely and is expected to be finished soon after the arrival of better weather.

NEWARK.—The Louis Sacks Iron Foundry has added a brick pattern storage building to the group of structures at Hamburg Place. The company manufactures semi-steel.

NEWFIELD.—Work is being rushed on the new glass factory at Newfield and it is expected a large force of men will be employed as soon as the plant is finished.

RIDGEFIELD PARK.—The Bergen Paper Mill will enlarge its plant and will increase its output by 50 per cent.

New Mexico

ALBUQUERQUE.—The J. G. White Engineering Corporation has been awarded a construction and engineering contract by the Senorito Copper Corporation of Senorito, N. M., in the Monticello District, 90 mi. northwest of Albuquerque.

The contract covers installation of a mill and power plant, a two-mile tramway, necessary mining machinery and equipment of the company's coal mine to produce fuel for the power plant. Initial installation will be for production capacity of a quarter million pounds of copper per month. Active work has been started and construction is being rushed in order to take advantage of the high price of the metal.

The mill and plant embody some unusual features enabling the production of refined copper at the mine and eliminating the necessity of transporting the ore. This will be accomplished by the Greenwall electrolytic method of leaching and electro-deposition.

New York

AUBURN.—The Cayuga Steel Company, Ltd., with a capital of \$300,000, is considering the selection of a site for a big factory in Auburn. The company is authorized to buy, lease, erect, equip and operate furnaces, mills, shops and plants for the production of, re-working, and manufacture of iron, steel and other metals and alloys.

NEW YORK.—The By-Products Company, 10 Broadway, New York City, is contemplating the addition to its plant of a boiler house at its plant on Shooter's Island, near Staten Island, to cost about \$125,000. A new tankage plant will also be erected at a cost of about \$150,000.

NEW YORK.—The Chemical Manufacturing Corporation, 200 Nassau St., will begin the manufacture of dyes about February 1. The president of the company is Spencer D. Embree.

SYRACUSE.—The Smet-Solvay Company plans to make extensive experiments and to take up the manufacture of intermediates and dyes. The company has begun the manufacture of salicylic acid and plans to take up other lines.

NIAGARA FALLS.—The American Magnesium Corporation, a new company, with a capital of \$300,000, will establish a factory at the far north end for the manufacture of magnesium. It is also authorized to manufacture magnesium, calcium and other metals. The directors are E. W. Burdick, I. J. Hallenbeck and J. J. Devereux, all of New York.

MONTICELLO, N. Y.—The Mont Color & Chemical Company has been formed to produce chemicals, intermediates and dyes from coal tar. Some equipment has been ordered but further purchases will likely be made in the near future. The company would like to receive catalogs from machinery and other houses. Mr. F. P. Brenner is manager.

Ohio

BELLAIRE.—Several of the glass factories in this section are experimenting with crude oil and coke on account of the gas shortage.

CANTON.—The United Furnace Company has started operations at its new blast furnace here. Its daily output is to be 450 tons. A by-product coke oven and benzol plant is also practically finished. The new furnace will supply hot metal to the United Alloy Steel Corporation.

CINCINNATI.—The Comfort Paper Company, recently incorporated with a capital of \$400,000, plans the erection of a large paper mill for the manufacture of book papers in the Millcreek Valley, not far from Cincinnati. The incorporators are George O. Comfort, of Kalamazoo, Mich.; M. J. Sullivan, of Cincinnati; William A. Stuart, of the Browne & Stuart Company; Charles E. Wing and Thomas H. Kelley.

CINCINNATI.—Plans being prepared by Ward Baldwin, consulting engineer, 809 Commercial Tribune Building, for erecting addition to Union Distilling Company's plant, Carthage; estimated at \$200,000.

LORAIN.—The United States Steel Corporation is said to be back of a \$200,000 land purchase here with the idea of erecting another steel plant.

Oklahoma

ALLEN.—The Crystal White Refining Company has recently increased its capacity from 300 to 1000 barrels a day.

Oregon

OREGON CITY.—The Hawley Pulp & Paper Company will shortly commence work upon its second big unit of the mill which it is erecting. The first unit has been completed and the machinery is now being installed. The total cost of this unit was \$1,000,000.

Pennsylvania

COATESVILLE.—The Lukens Iron & Steel Company will erect a new mill for the rolling of steel plates which will be the largest similar unit in the world. The new mill will be 17 feet wide, capable of rolling plates up to 192 inches in width. The two largest mills in the United States at present roll 152-inch plates and a 168-inch mill is the limit of the British Isles. Coatesville, with the extension of the Lukens Company and the expenditure of \$10,000,000 on company and the Worth Bros. plant, is rapidly forging to the front as a steel manufacturing center.

HARRISBURG.—Mr. L. M. Lawson, of Bridgeport, Conn., has recently been in Harrisburg on a visit to inspect a project for the growing and refining of sugar beets in this community. If possible a plant will be built with local capital.

JOHNSTOWN.—The Franklin plant of the Cambria Steel Company has broken ground for two new buildings to cost \$3,000,000. A car wheel plant to cost \$4,000,000 will also be built. Further extensions are expected but have not yet been officially announced.

MARCUS HOOK.—Some interesting figures on the growth of Delaware County last year are presented. New buildings were put up by the Benzol Products Company, General Chemical Company, Conolum Company, Viscose Company, Sun Oil Company, all in Marcus Hook, reaching an approximate cost of \$5,000,000.

SOUTH BETHLEHEM.—The Bethlehem Steel Company has announced that it will erect an Ingot and casting plant with a capacity of 500 tons a day. The foundry will be equipped with the very latest appliances and will cost \$750,000.

Tennessee

CHATTANOOGA.—The Lookout Paint Company, whose plant was destroyed by fire, will rebuild same and within thirty days expects to have temporary building erected and a portion of the plant put in operation.

Texas

HOT-SPRING.—A large tract of land on the Sabine-Neches Canal, between Beaumont and Port Arthur, has been purchased by E. L. Doherty, of California, who expects to erect a \$2,000,000 refining plant for refining oil.

Utah

SALT LAKE CITY.—Local capitalists interested in the Lake Cache Sugar Company have been selecting sites in Northern Utah for a new sugar factory. The company has purchased the Knight Sugar factory at Raymond, Canada, which will be moved to Utah.

Virginia

HOPWELL.—The Dupont Company has awarded contract to the Westinghouse Electric Company for a large electric generator for its new nitrogen plant under construction at City Point. The new generator will have a capacity of 25,000 horsepower.

Washington

PORT ANGELES.—Whalen Brothers, of Canada, are understood to have under consideration the erection of a large paper pulp mill in Port Angeles, Wash. The enterprise has been financed by Peabody, Houghteling & Co., of Chicago. Construction of the plant will begin about the first of February and will be finished in eight months. It is expected that their paper mills will be erected on Puget Sound in the near future.

SPOKANE.—The Berlin Dye Works plans the erection of an addition to its plant. Mr. Joseph Mackoff, proprietor, has left for Chicago to purchase new machinery.

TACOMA.—Owing to increased capacity at the plant of the American Smelting & Refining Company here (refineries nearly double in size), the company will erect a new stack for carrying off gas, etc. The new stack will be 350 feet high, 30 feet higher than the one at Butte, which now holds the record, and will be 25 feet in diameter at the top. The new stack will be equipped with a Cottrell precipitator for recovery of fine metallic dust. The present stack is equipped with this apparatus and from 10 to 15 tons of fume per day are recovered in this manner. The new stack it is expected to recover 30 to 40 tons per day.

TACOMA.—The Standard Chemical Company will commence the erection of new buildings for house machinery, etc., for the manufacture of caustic soda, and flotation oils. The cost of the new plant will be between \$7,000 and \$8,000. The company is chiefly engaged in the manufacture of coal-tar derivatives, disinfectants, etc.

West Virginia

GRAFTON.—The Hazel-Atlas plant, which manufactures glass, is growing rapidly. The original plant is now practically completed. The plant is turning out about four cars of finished product per week. The company expects to commence the erection of a second tank on the original site in the near future. With the second tank running and if the gas department is successful in supplying the required amount of fuel, the company looks forward to putting in another plant of exactly the same type at the east side of their property.

WHEELING.—American Bottle Company, subsidiary of the Owens Bottle Machine Company, 30 East Rand Street, South Chicago, will erect \$2,000,000 plant here for the manufacture of glass bottles.

WHEELING.—The Whitaker-Glessner Company of Wheeling will erect a large sheet mill on its Beech Bottom property. The plant will consist of eight hot mills and is expected to be ready by August.

Wisconsin

STEVENS POINT.—The Whiting-Plover Paper Company will make improvements costing \$100,000 during the coming year. A new mill costing \$50,000 and two new water wheels will be the most important items.

Canada

CHATHAM, ONT.—In the Calgary field the Calgary Petroleum Products Company has installed a small experimental refining plant at its wells near Okotoks. The company is preparing plans for a larger plant. In the Tilbury gas field the Union Natural Gas Company has finished a gasser on the Chris Armstrong farm near Glenwood.

The Imperial Oil Company, which constructed several new stills at its Sarnia refinery, is stated to be planning other large extensions in 1917. The Perfection Stove Company and allied concerns has recently constructed a large addition to its factory.

Manufacturers' Notes

FERROCHROMIUM NOW MADE ON PACIFIC COAST.—The first fifty-ton carload of ferrochrome produced on the Pacific Coast was shipped East on Jan. 15 by the Noble Electric Steel Company. The Noble Company is doing a large business at present.

PAPER EXPORTS DOUBLED.—Exports of paper and paper manufactures this year

will reach \$40,000,000, doubling those of any previous year, according to figures assembled by the Bureau of Foreign and Domestic Commerce.

News print paper exports this year have reached a total value of \$3,430,000 against \$2,260,000 last year, about half of it going to Latin-America. It would seem that there are other countries besides Europe, Asia and high cost of raw materials for our high paper prices.

AMERICAN FIRM GETS BIG ARGENTINE CONTRACT.—The second largest contract ever awarded by the Obras Sanitarias de la Nación, of Buenos Aires, Argentina, was obtained recently by an American firm. The United States Cast Iron Pipe & Foundry Company will supply 60,000 tons of pipe, amounting to about \$3,500,000. The American commercial attaché at London, England, was of assistance in bringing this contract to the United States. A report on the subject has been received from Secretary L. B. Clark, in charge of office of commercial attaché, Buenos Aires.

BRITISH EXPORT PROHIBITIONS.—By an Order in Council dated December 12, according to the "Chemical Trade Journal & Chemical Engineer," manganese, peroxide of, and mixtures and preparations thereof; thorium and its alloys; and zirconium, and its compounds and alloys, are added to the list of goods the exportation of which from the United Kingdom is prohibited to all destinations. Lead (except pig lead), alloys of lead, solder containing lead, and manufactures of lead, or its alloys, not otherwise prohibited; oil varnishes; zirconium minerals; and fish bones are prohibited from exportation to all destinations abroad other than British Possessions and Protectorates. Lead, not otherwise prohibited; iridium, osmium, palladium, rhodium, and ruthenium compounds; white lead; oxalates, not otherwise prohibited; sodium, potassium, and thiosulphates, metallic, not otherwise prohibited; animal hoofs and other glue stock; glue, osseine and concentrated glue, size, fish glue, isinglass, finings and other kinds of gelatine; iridium, osmium, palladium, rhodium, ruthenium, and alloys of these metals are prohibited from exportation to all foreign countries in Europe and in the Mediterranean Sea, and elsewhere other than France, Russia, (except through Baltic ports), Italy, Spain, and Portugal.

The following headings scheduled in previous Orders are deleted: Manganese peroxide, prohibited from exportation to all destinations; and lead, pipe, scrap, or sheet, and solder containing lead, prohibited to all destinations abroad other than British Possessions and Protectorates.

LARGE ORDER FOR CHLOROBENZOL.—The Federal Dyestuff & Chemical Company, Kingsport, Tenn., is reported to have received an order for 3,000,000 pounds of chlorobenzol, and will be executed by the company's new plant at Kingsport.

The goods are for export, and it is expected that the order can be executed within the next six months, with the capacity increased and rapidly increasing capacity of the plant.

Chlorobenzol is an "intermediate" used in the manufacture of dyes, and the Kingsport plant is now equipped to turn it out in large quantities. The demand for this chemical is heavy, and the price is far above normal.

EXPORTS FROM GERMANY TO UNITED STATES FOR 1916.—The total value of the exports invoiced at the American consulates in Germany for the United States during 1916 was \$3,361,900, against \$39,967,183 for 1915. Exports to the Philippines were valued at \$21,428 against \$140,871. No exports were declared during the year for Hawaii or Porto Rico, while in 1915 the shipments were valued at \$89,159 and \$16,841, respectively. Returned American goods were valued at \$2,400, against \$178,546 for 1915.

CONDITIONS IN SWISS DYESTUFF INDUSTRY.—The Swiss dyestuff industry has had to cope, according to Chemical Reports with great difficulties in connection with labor and materials. There are no coke ovens in Switzerland, and the coal-tar products and procuring them have been those which could be spared by belligerent countries, chiefly England. There is only one sulphuric acid works for the dyestuff factories, nitrites, nitric acid, caustic soda, and chlorine are plentiful.

The Swiss dyestuff factories have had to supply the requirements of the home consumers, who formerly dealt almost entirely with Germany, and who are now busy with foreign orders; nevertheless a

considerable quantity has been exported under government supervision in return for raw materials allowed to come in. The price of aniline oil has risen to ten times the normal.

The Swiss silk-dyeing industry is suffering through scarcity of vegetable dyestuffs, particularly logwood. Stocks are nearly exhausted.

ADDITIONS TO BRITISH CONTRABAND LIST.—A proclamation of December 29, 1916, supplements the following as additional absolute contraband:

Oxalic acid and oxalates, formic acid and formates, phenates, metallic sulphites and thiosulphates, soda, lime and black-china powder, platinum, osmium, ruthenium, rhodium, palladium, iridium, and alloys and compounds of these metals, strontium salts and compounds thereof, barium sulphate (barites), bone black. Schedule I, proclamation of October 14, 1915, is amended as follows: For item 8, "ethyl alcohol, methyl alcohol," substitute "alcohols, including fusel oil, wood spirit and their derivatives and preparations"; for item 35, "aluminum, alumina, and salts of aluminum," substitute "aluminum and its alloys, alumina, and salts of aluminum"; for item 36, "wolframite, scheelite," substitute "tungsten ores"; schedule II, for item 5, "fuel other than mineral oils," substitute "fuel, including charcoal, other than mineral oils."

DUST COLLECTING COMPANIES RE-ORGANIZING.—The Clark Dust Collecting Company, Chicago, Ill., announces that it has severed its connections with the Simon, Buhler & Baumann Co., Inc., New York, a Western enterprise, and that they have consolidated with the American Dust Collecting Company to build a full line of dust collecting apparatus, including the American suction filter.

RENNERFELT FURNACES IN THE UNITED STATES.—The following Rennerfelt furnaces are in operation or building in the iron and steel industry in the United States:

Crucible Steel Company of America, Crescent Works, Pittsburgh, Pa. Capacity, 750 lbs., 100 kw. steel steel.

Charleston Steel Company, Charleston, W. Va., 6-ton, 1200 kw. special steel ingots.

Two furnaces, American Foundry & Machine Company, Salt Lake City, Utah, 3-ton, 625 kw. steel castings.

Edgitt Steel & Iron Works, Sedro-Woolley, Wash., 1-ton, 200 kw. steel castings.

Parsons Company, Newton, Iowa, 1-ton, 200 kw. steel castings.

The Samson Iron Works, Stockton, Cal., 1-ton, 300 kw. steel castings.

Ducas & Company, New York City, 3-ton, 750 kw. steel ingots.

J. Leslie & Co., St. Louis, 200 kw. tool steel, Philadelphia, Pa.

Maynard Steel Castings Co., Milwaukee, Wis., 1-ton, 300 kw. steel castings.

New company in Minnesota, not at liberty yet to mention name, 3-ton, 600 kw. steel castings.

Pacific Foundry Company, San Francisco, Cal., 750-lb., 100 kw. special iron castings.

New company, but not at liberty to mention name, 1-ton, 300 kw. steel castings.

Besides this there are two Rennerfelt furnaces of 300 lbs. capacity in the pipe and brass industry, and one of this size for refining ferro-tungsten, another one for melting special aluminum alloys, besides ten special furnaces for making low carbon ferrotungsten.

SULPHURIC ACID IN 1916.—The production of sulphuric acid in the United States in 1916 was much greater than in 1915. The estimate is stated in the Geological Survey of sulphuric acid of strengths of 50°, 60°, and 66° in 1916, expressed in terms of 50° acid, is 4,475,000 tons, an increase of 600,000 tons, or more than 15 per cent. The increase was distributed about equally between acids of strengths of 50° to 60°, and acids of 60° to 66° increase in the production of acid of strength of 66°.

The most notable feature in the sulphuric acid industry was the enormous increase in the production of acids of strengths greater than 66°. The estimate shows a production of these stronger acids of over a million tons as against a production of less than 200,000 tons in 1915. It is not feasible to express the amount of these higher acids in terms of 50° acid; therefore the total given for them is in addition to the total given for acids of strengths of 66° or less.

The estimated output of acids of strengths of 60° and 66° includes by-product acid produced in copper and zinc smelters. The output of acid so produced in 1916, expressed as 60° acid, amounted

to nearly 950,000 tons, or practically the same as in 1915. However, over 110,000 tons of acid of higher strengths was produced at these smelters, a quantity nearly double the product of 1915.

The market conditions throughout the country are reported to have been on the whole better than in 1915, and the value of the product will probably be somewhat higher than it was even during that year.

MANGANESE IN 1916.—Preliminary estimates by D. S. Hewitt, of the United States Geological Survey, Department of the Interior, show that the production of manganese ore in 1916 was about 27,000 tons, the greatest since 1891, when it was 3,000 tons.

The estimate does not include manganeseiferous iron ores that contain less than 40 per cent of manganese, but it is very probable that the production of ores of this class also was much greater than in 1915. This output has come largely from seven states, and the order in production will probably prove to be as follows: California, Arizona, Georgia, Virginia, Colorado, Utah, Colorado.

This order is interesting, because this is the first year in which a western State remote from the steel-producing centers has contributed the largest amount of manganese ore.

The activity among manganese mines in California is due largely to the market for ores provided by the Noble Electric Steel Company. It is not yet possible to state the production of high-grade ores adapted for use in dry batteries, but reports indicate that it will exceed 2,500 tons, and therefore five times that in 1915.

There are now produced in Arizona, California, Utah, Colorado, and Virginia, but the amount produced is still scarcely one-tenth the normal demand.

Prices for manganese ore have been adapted to the manufacture of ferro-manganese rose from a maximum of \$22.50 for 50 per cent ore in 1915 to \$32.50 in March, 1916, except for fluctuations which depended on temporary variations in demand, prices were nearly constant until the last month of the year, when sales at prices as high as \$39 for 50 per cent ore were reported.

There were rumors that a contract for the delivery of 200,000 tons of Brazilian ore during 1917 was placed at \$23 per ton f. o. b. Brazilian ports, from which the freight rate to the interior is \$18 a ton.

Ore adapted to the manufacture of dry batteries (containing 80 per cent of manganese dioxide and less than 1 per cent of iron) continues to sell for about \$55 a ton.

Imports of Manganese ore for the first ten months of 1916 amounted to 495,299 tons, of which 401,177 tons came from Brazil.

For the same period of 1915, Brazil supplied 181,258 tons out of the total of 192,286 tons. There is a prospect, therefore, that the imports for the entire year will prove to have been almost double.

Considering the small part of the demand that was supplied by Brazil during the eight years prior to 1914, it is reassuring to know that the deposits of this country can be made to yield such enormous quantities of ore. Imports from India, Cuba, Panama, and Japan were also greater than in 1915.

Imports of ferro-manganese for the first eleven months of 1916 were 73,425 tons, which is nearly 50 per cent more than for the corresponding period in 1915, though bearing a smaller ratio to the domestic production. Prices reached the highest figures ever recorded in the United States in April, 1916, when, it is reported, \$400 a ton was paid for a small lot for immediate delivery.

For the period of 1915, the price of this product declined steadily to \$160 a ton in October, then rose to \$175 again in December. The price of spiegeleisen carrying 20 per cent of manganese ranged from a maximum of \$52 in July to \$40 in December.

An important consequence of the prevailing high prices of manganese alloys is the attempt on the part of steel makers to use ferro-silicon. The extent to which substitutes for manganese in steel may be used has not been determined, but experiments by several steel works show that an alloy of iron, carbon, and uranium may be satisfactorily used to replace a part of the ferro-manganese commonly added.

Although a number of mines in Virginia, Colorado, and Arizona were reopened during 1916, the greatest activity is reported among mines in California, Arizona, Utah, New Mexico, and other western States.

This is due in part to the operation of the steel reduction plants in California and Washington, but more largely to the low percentage of iron in some of the western ores.

Few eastern mines that operate on small deposits can afford to produce in large quantities ore that contains less than 1 per cent of iron, and therefore most of

the eastern mines ship their product to eastern furnaces to be reduced to ferro-manganese. The inaccessibility of most western deposits makes it unprofitable to ship ore to eastern makers of ferro-manganese, even at the high prices they are now offering for manganese ore. On the other hand, many western deposits are known and more have been discovered during recent years, which are capable of producing manganese with less than 1 per cent of iron. At prevailing prices for such ores, they may be profitably shipped as far east as New York. There is a prospect that several western mines may be present to ship high-grade ores to eastern markets even when prices recede to the level of years prior to 1914.

ITALIAN FIRM WANTS CATALOGS.—The firm of Bonaparte & Salvini, 76 Foro Bonaparte, Milano, Italy, is desirous of receiving catalogs, prices and conditions of sale from American manufacturers of electrical apparatus and other industrial material.

BONUS FOR CUTLER-HAMMER EMPLOYEES.—The shop employees of the Cutler-Hammer Manufacturing Company of Milwaukee, all received a Christmas bonus on or about the 23rd of December, and before New Year's Day a notice was posted which advised everyone of a bonus of 10 per cent of the year's earnings or salary. This bonus went to all of the 2,400 employees of this company.

MOULTON ENGINEERING COMPANY OPENS NEW YORK OFFICE.—The Moulton Engineering Corporation of Portland, Me., announces the opening of a New York office in the Woolworth Building. Mr. Horace W. Flashman, who for a number of years has been connected with the Western Electric & Manufacturing Company, will be in charge of the office.

The company is prepared to render service in general, civil, mechanical, and electrical engineering, and in the development of special process. The company is also associated with the Electron Chemical Company, manufacturers of the Allen-Moore electrolytic cell.

Manufacturers' Catalogs

ESTERLINE COMPANY, Indianapolis, Ind. Esterline graphic efficiency instruments model E. B. catalog No. 369. Clocks, ammeters, voltmeters, wattmeters, speed recorders.

KIESELGUHR COMPANY OF AMERICA, 11 Broadway, New York City, S. I. Co. Cell products for heat insulation, boiler settings, hot air stoves, flues, furnaces, kilns, ovens, etc.

MESTA MACHINE COMPANY, Pittsburgh, Pa. Mesta improved pickling machines. Patented. Used in chemical and fertilizer plants and a large number of miscellaneous metal products.

SPRAY ENGINEERING COMPANY, Boston, Mass. Spraco evaporators for washing and cooling of steam turbine air for steam-turbine driven generators.

Other New Publications

PEAT IN 1915. By James S. Turp. Geological Survey Report.

STONE IN 1915. By G. F. Loughlin. Geological Survey Report.

THE SUICIDE OF THE HORSESHOE FALL. By John Lyell Harper.

THE NUMERICAL CORRELATION OF PHOTOGRAPHY. Issued by the Research Laboratory, Eastman Kodak Company, Rochester, N. Y.

ORGANIZATION, PLAN AND SCOPE OF THE NATURAL RESOURCES SURVEY OF CANADA. Bulletin No. 1, issued by the Natural Resources Survey. Arthur D. Little, Ltd., Montreal, Director.

A USEFUL LAMP FOR OIL MEN. Complied by Thomas P. Melvin, issued by the Phoenix Refining Company, Tulsa, Okla.

THE ANALYTICAL DISTILLATION OF PYROLYSE. By W. F. Rittman and E. W. Dean, issued by the Department of the Interior, Bureau of Mines, Washington, D. C.

A GENERAL SUMMARY OF THE MINERAL PRODUCTION OF CANADA DURING THE CALENDAR YEAR 1915. By John McLeish, issued by the Canada Department of Mines, Mines Branch, Ottawa, Can.

GEOGRAPHY OF THE UPPER ILLINOIS VALLEY AND HISTORY OF DEVELOPMENT. By Carl F. Swain, issued by the United States Geological Survey, University of Illinois, Urbana, Ill.

THE PRINCIPLES AND PRACTICE OF SAMPLING METALLIC METALLURGY. CAL. MINE. BULL. By Edward Keller, Bureau of Mines, Bulletin 122. The bulletin devotes special attention to the sampling of copper bullion.

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Contents for February 15, 1917

EDITORIAL:

The Niagara Falls Power Famine.....	175
Tonnage of Iron in Future.....	176
On the Blindness of Others—and Ourselves.....	177

READERS' VIEWS AND COMMENTS:

The Flotation Suit Decision. By a Metallurgical Engineer.....	178
Electrolytic Oxidation of Sulphurous Acid. By Maurice R. Thompson and M. deKay Thompson.....	178
More Publicity Urged on Industrial Research Labora- tories. By A. E. Kennelly, J. W. Richards, A. Sauvœur, A. N. Talbot and C. C. Thomas.....	179
Who?.....	180
Coming Meetings and Events.....	180
National Safety Council Broadening Its Activities.....	180
Award of the Elliott Cresson Medal to E. F. Northrup.....	180
The Western Metallurgical Field.....	180
Philadelphia Hearing in Miami Flotation Suit Before Court of Appeals.....	181
Chemical and Electrical Porcelain.....	182
Methyl Alcohol and Acetone as By-Products of the Soda Pulp Industry. By Alfred H. White and John D. Rue.....	182
Current News and Notes.....	184
Air Drying. By Carl Herling.....	187
The Effect of Centrifugal Force on Colloidal Solutions. By Eugene E. Ayres, Jr.....	190
The Carbonization of Kelp for the Recovery of Potash. By J. W. Turrentine.....	196
The History and Legal Phases of the Smoke Problem. By Ligon Johnson.....	199
Spring Meeting of American Chemical Society.....	204
Potash as a Byproduct from the Blast Furnace. By R. J. Wysor.....	205
Silica Brick and Some New Uses for Them. By Walter Gray Movement for Increased Adoption of Metric System Gaining Headway.....	216
The Processes of the Organic Chemical Industry Used in the Manufacture of Intermediate Products. By A. H. Ney and D. J. Van Marle.....	217
SYNOPSIS OF RECENT METALLURGICAL AND CHEMICAL PATENTS.....	224
RECENT METALLURGICAL AND CHEMICAL PATENTS.....	227
The Utilization of Waste Products and of Low-Grade Fuels for Power Generation. By John B. C. Kershaw.....	229
PERSONAL.....	232
BOOK REVIEWS.....	233
Current Market Reports—The Iron and Steel Market, Non- Ferrous Metal Market, Chemical Market and Price-List.....	233
Industrial—Financial, Construction and Operation, and Manu- facturers' Notes.....	237

The Niagara Falls Power Famine

A un point de vue plus objectif il est bien évident que cette
crise de la houille blanche à Niagara Falls est l'indice que
les Etats-Unis sont beaucoup plus pauvres qu'on ne se
l'imagine en forces hydrauliques. Et il ne faudra pas perdre
de vue plus tard cette indication quand on étudiera l'orienta-
tion de certaines fabrications électrochimiques.

Thus the *Journal du Four Electrique* in its issue of
Jan. 1, 1917, and we would respectfully submit the re-
mark to the distinguished consideration of the eminent
gentlemen in Washington who will be so largely respon-
sible for the future of electrochemistry in the United
States.

At this writing the Cline bill has passed its third read-
ing and the permanent legislation in regard to Niagara
power which it proposes includes, of course, the inevit-
able tax on the water used. Equally inevitable appears
the fate of the bill when it goes to the Senate, which will
refuse consent to the tax. This means amendment fol-
lowed by conference and then nothing will be done.

Meanwhile, with the nation facing the probability of
war, munition plants and all kinds of industries, abso-
lutely necessary to a country at war, dependent on the
products of the Niagara Falls electrochemical industries,
must suffer because the eminent gentlemen in Washing-
ton know the value of the monopoly scare as a vote
catcher.

The temporary relief measure passed by Congress is
not of the very smallest benefit to the United States. In
the first place, ice is not a satisfactory source of power.
and at the present time weather conditions are such that
the additional water is in this unavailable form. Sec-
ondly, when the weather improves conditions will be far
worse than before owing to Canadian demands. Canada
knows what war means and hence the demand for 50,000
hp. by April 1st will be insisted on and will be obtained
by the simple process of cutting off this amount of power
from the United States. Finally, unless some unfore-
seen event changes present Canadian developments no
power whatever will be exported from Canada to the
United States by the end of this year.

Let us consider what this means. According to for-
mer legislation 160,000 hp. could be exported from Can-
ada to the United States. Our electrochemical indus-
tries counting on this import and the normal improve-
ments in the efficiency of hydro-electric developments
have built their great plants and made themselves a vital
necessity to the whole country. Now in the time of our
need we have a power famine which in a few months
will be infinitely more serious than at present. Of the
160,000 hp. formerly available not a mouse-power will
come from Canada.

The additional 4400 cu. ft. ought to give us 80,000 hp.

if developed at high efficiency and the water now used would give an enormously increased power were it used in the efficient manner made possible by the modern improvements in hydro-electrical engineering. None of this, however, is possible so long as the inexpert bungling of legislators prevents the necessary developments. As far back as 1906 when the infamous Burton Act was passed the Niagara Falls Power Company had all its plans completed for finishing its great pioneer work begun in the last decade of the nineteenth century. Had it not been for that Act, Niagara Falls would long ago have had from this development 200,000 hp. in a plant showing the highest attainable efficiency. Even had some common sense penetrated the legislative mind in 1909 when the Burton Act expired, this work would have been undertaken, but the monopoly-scare mongers were busy and all thoughts of efficiency and the conservation of our resources from a strict engineering standpoint as well as from the broader viewpoint of national industry were disregarded.

It cannot be too often or too strongly insisted that we shall never get the full efficiency out of the water taken from the Niagara River until permanent, common-sense legislation warrants the great expense involved in taking advantage of modern hydro-electric engineering principles and methods.

Once more with war threatening us and the country looking to Congress for legislation that will put us in the strongest position to face its strain as well as that of the economic struggle which will follow it, our legislators have an opportunity to retrieve the disastrous blunders of the past, blunders which have caused a power famine daily increasing in intensity and which the whole country will feel before many months are past. Will this opportunity be let slip for the sake of collecting a small revenue or to please the dupes of the monopoly-scare monger? Every cent of a tax of this kind is simply a hindrance to the attainment of the ideal in the efficient use of water power and is surely borne by the electrochemical industries and those dependent on their products. For the purpose of collecting a small revenue the larger indirect revenue to be derived from the industries supplied by the hydro-electric power is sacrificed and the welfare of the whole country injured to an extent that it is impossible to estimate.

Truly the Washington efficiency engineer has a single eye to political conservation.

Tonnage of Iron in Future

It has always been difficult to believe that the rate of growth previously maintained in the American iron and steel industry could be maintained in future. The fact that the growth in tonnage had been in geometric ratio was in itself suggestive that it could not continue in the same fashion. In the years immediately following the panic of October, 1907, it was felt in many quarters that at last the time had arrived for the rule to break down, that indeed it had broken down. The large tonnages lately produced, however, have practically put the rule in operation again. As shown in

these columns Sept. 15, 1916, pig iron production in the decade ended Dec. 31, 1915, compared with output in preceding decades, was very nearly in conformity with the old rule of a doubling every ten years. In 1916 the output was much larger, and 1917 promises a gain, where a comparison made by using the decade ending with the present year will show a still closer conformity.

We can look into the future with clearer vision than one decade or two decades ago, because we have more history to guide us. The increase in the use of steel and iron is no longer mysterious. When mild steel was a new thing a structure made of it was regarded as a permanent work, not altogether like the pyramids, perhaps, or like the iron pillar at Delhi, now nearly if not quite 3000 years old and still "going strong," but at any rate something about which it was reasonable to wonder how long it was capable of lasting. Now we know it is more likely to be a question of how long men will continue to need it. Skeleton steel buildings only ten years old have been torn down to make way for much taller structures with much heavier members.

For the consumption of iron per capita to remain the same it would, of course, be necessary for the population to increase at the same rate as the production. This, of course, it has not done. If the population growth were in geometric ratio it would not be in as great a ratio, and the per capita consumption would have to increase. Population growth, however, has not even been in geometric ratio. It was so, approximately, from 1790 to 1860, the increase per decade being about 35 per cent, but in the three following decades the increase was only about 26 per cent, while the decennial increase from 1890 to 1910 was still smaller, 21 per cent.

The production of pig iron per capita was about 94 lb. in 1870, 330 lb. in 1890, and 670 lb. in 1910, while it is now about 930 lb., taking only the population of continental United States.

It is really a question of the needs and purchasing ability of the people. The wealth of the United States doubles in a little more than a decade. The freight ton-mileage of the country has been doubling about once in every dozen years.

The rapid growth of the automobile industry is often cited as an illustration of the expansion in the use of steel. We beg to use the illustration of the automobile industry just the other way. When people buy 1,500,000 automobiles in a year at, say, \$800 apiece, they are spending nearly a dollar for every pound of iron thereby absorbed, an enormously expensive way to provide an outlet for iron. It is no illustration at all. Rather one should view the case that the people are rich enough so that more than a million new owners a year appear, and soon they will be well provided and part of the money will be spent otherwise.

The laying of petroleum pipe lines, which has consumed more than a million tons of iron and steel, did not noticeably interfere with the growth of rail freight traffic, nor will the automobile. The past few years

have been bad with the railroads, from too much saying by state and federal governments of what they must not do, but soon, there is good reason to hope, will come the time when the government will tell the railroads what they must do by way of expansion to meet and anticipate the needs of the country, and will assist them, if necessary, in the expansion. The advent of the steel freight car and heavier locomotives forced the railroads, ten years and more ago, to relay nearly all their track with heavier rails. Now still heavier cars and locomotives are coming, and when the scruples of the railroads as to the quality of a 125 or 150-lb. rail, as compared with an 85-lb., are removed, another era of rail replacement will come. Then there is electrification, no longer a technical problem, but almost wholly a financial one and commercially this will be perhaps the biggest development of all; and we may add in parenthesis, it may affect the copper industry even more than the steel industry.

There are few uses for steel in which a large expansion in tonnage cannot with confidence be predicted. Most of these lines of consumption, hydroelectric development as a conspicuous instance, are in their infancy as compared with railroading, which promises heavy consumption in future.

It has been suggested that as time passes and the amount of iron and steel in use increases, the amount to be won from the ground by ore mining will not need to increase so rapidly, as more scrap will be returned after use. It is a question of mathematics. If the proportion of the production that will eventually come back, as against that which is totally lost by oxidation and comminution or dispersion or whatever it may be called, remains constant, and the average period of life remains constant, then with a geometric rate of increase in consumption the rate of increase in production will not change. If production doubles each ten years, and one-half comes back as scrap in ten years, then the scrap will always be one-fourth the production. If it is twenty years instead of ten the proportion will always be one-eighth. If the period of employment lengthens, the proportion of scrap to supplement new production will decrease. If the period of employment decreases, the smelting of iron ore will increase by smaller ratios, but the activity in reworking will increase.

On the Blindness of Others—and Ourselves

The other day a woman who ran an army canteen in England last year related how, with the problem often before them to feed several hundred soldiers on absurdly short notice, no labor saving devices were at hand, no dish-washers or bread-cutting or sandwich machines were available; in fact, there was nothing provided to save work.

In John Masefield's book on the ships of Nelson's day it is noted that "eart of hoak and other lumber was seasoned in water and that the British ships were heavy and damp and unwholesome in consequence; yet they would not change their methods. The Yankee clipper ships were built on French models and were far more

speedy and desirable, but nothing could drive into the heads of those British shipbuilders the idea that it is better to season wood than to soak it.

Before these days of blood and anguish a very distinguished American engineer went through the Krupp works at Essen. With great pride they showed him seventeen men at a job successfully accomplishing what it takes three men to do in Pennsylvania, and in another place a military company of marching men were doing the work of a chute.

If we only close our eyes to the inward glance; if we address ourselves to looking very hard at other people and neglect the thought of our own short-comings, it does seem as if those foreigners were dunderheads for fair. This is a habit with us. We may admit that we have single faults but other people are promiscuously and miscellaneously wrong. Ask any Democrat what he thinks of the Republicans and he will say they have no character and no ideals, and the Republican will say of the Democrats that they have no sense. We are right and the other fellows are wrong.

Now we respectfully submit the gospel of modesty. We can give plenty of reasons but we can give no excuse for our beehive coke ovens. We can explain the wretched condition of our army, but that does not excuse it. We can explain how some industries use up men and take the hearts out of them whereby discontent and disorder and hatred and malice are caused to thrive like a green bay tree, but that does not excuse them. We can point with pride to the expedition with which living shacks for workmen have been constructed, but if they are unwholesome or even ugly we should do better to recall the pride, send for a sanitary engineer and get busy.

In the big vision of things explanations do not excuse. The sooner we get this into our heads and hearts the better it will be for us. All the world's a stage—it's a regular exhibition, and all our works are on show. We cannot attach our personal labels to them, however, whether we want to or not, for more than a very little while. Our works are on show as the product of the people of the United States and that is the only label that will stick. The people of the United States have fallen short in many ways, and all of us have had a hand in it.

The whole world is in a very bad way and most of the children of the earth see red and red only. Now Crile and many others have shown the inwardly destructive force of anger, and by this a great part of the world is being crippled in mind as well as in body. We shall have that to meet, and to avoid, if we would keep our heads, no matter how much fighting we may have to do. What we need above all things to-day is the philosophic vision that looks for the right, that sees our own faults and tries to remedy them. It is always bad diplomacy to point out their faults to other peoples. They have to find them out for themselves by reason or by force of circumstance. Talking will do no good. But our own lapses are excellent subjects for us to consider. They are not such pleasant subjects as the faults of others, but they are vastly more wholesome.

Readers' Views and Comments

The Flotation Suit Decision

To the Editor of Metallurgical & Chemical Engineering

Sir:—A very interesting letter signed "A. B. C.," appears in Feb. 1 issue of your journal re the legal status of flotation. One can agree with the digest of the writer and yet not accept his conclusions that the Supreme Court has made any mistake or is likely to change its mind.

All agree that the U. S. Patent Office is not what it was intended to be, and that litigation is of such a nature and expense that the inventor has little chance, and only when large capital undertakes the defense of a patent, as in the flotation cases, can the patent get a fair hearing.

The flotation case is one of the first instances where industry has been checked by the courts, and forced to recognize an invention that it adopted and used in defiance at immense profit.

The argument of "A. B. C." as to the academic knowledge previous to U. S. Patent No. 835,120 was all known and admitted, the commercial use of any of this knowledge was non-existing, yet there was great commercial necessity to find a commercial process. The court practically disposed of all this previous art under the fair assumption, knowing the conditions, that none of it was commercial.

If it was an obvious engineering feat to find a minimum and commercial percentage of oil, it had not been done, and the courts decide it was thus not obvious.

While a mere question of degree is not a patentable thing under our law, where the question of degree develops a large commercial practice, even though the difference in results is hard to define, there is an obvious discovery in the art or large commercial practice would not follow.

It appears a very just decision that there was invention under U. S. Patent No. 835,120, and that some degree of range in practice must be adopted to define infringement. One per cent was given as a convenient gross amount of oil.

If industry has now discovered that more than 1 per cent of oil is equally useful, it is their right to use such degree, but this cannot in any way reflect upon the opinion of the court, because this knowledge was discovered long after, and as a result of long experience with less than 1 per cent of oil, which gave birth to the flotation industry.

As to who was the true inventor of less than 1 per cent of oil is not now at issue, as Patent No. 835,120 has the legal status. The courts found justly that a large commercial practice followed at once the discovery that less than 1 per cent of oil was practical and sustained the patent that described such.

The purpose of the Patent Office is to encourage invention by offering reward to inventors in the form of royalty protection, and thus create advance for the community.

The result has for many years been very disastrous to inventors who are not capitalists and have no time for business practice.

Industry made the discovery that it could employ counsel and cause court delays and so defeat the just reward of invention, and that such practice was more economical than paying royalties. This is in direct defiance of the patent laws which grant a period of

royalty protection, because the refusal to pay royalty discourages invention and delays community advance.

In the end the present practice of industry is a short-sighted one as a community loss is the greatest that can occur.

The flotation decision is a most valuable precedent, and probably establishes the fact that invention that brings commercial practice will be protected, irrespective of academic theory or engineering practice that become obvious after the patent was issued.

How much better it would be for industry to aid the inventor, where they desire to use his invention or supposed invention, and advance him money to test the validity if in question, and thus prevent capitalizing of patents solely for monopolistic purpose.

The practice of attempting to own the inventor or force him to assign at a nominal price, or before there is any established value, should be deplored as a form of piracy.

Invention or research is a vital force that precedes all industry advance, and while radically different in mentality is in our advanced civilization perhaps quite as important. Even though the ownership of the flotation patents is to be deplored, if the lesson is learned by industry to deal with the inventor directly and permit him to hold and administer his inventions, aiding him in so doing, it is cheap even at the price of \$50,000,000 more or less that it may cost industry to settle its bills.

The inventor should profit only by the commercial value and validity of his invention through royalty. Industry should be glad to pay royalty in commercial degree as community progress, and profit solely by manufacturing and salesmanship.

There should be no such thing as control of common commodity patents by industry.

The interpretation of the law by the courts is practically always an echo of public opinion of the same kind, and "A. B. C." will do well to look a little beyond the argument he presents.

METALLURGICAL ENGINEER.

Electrolytic Oxidation of Sulfurous Acid

To the Editor of Metallurgical & Chemical Engineering

Sir:—I was much interested in the article by Messrs. M. De Kay Thompson and N. J. Thompson on "The Electrolytic Oxidation of Sulfurous Acid," page 677 of your issue of Dec. 15, 1916. This subject has been of no small importance in the field of copper leaching investigation where the copper is obtained by the electrolysis of a sulfate solution and the possibilities of making acid and lowering cell voltage by the utilization of such an anode reaction become worthy of attention. Of course, the same subject is intimately connected with several important lines other than copper leaching.

It would be interesting if Messrs. Thompson would give us figures and a discussion on the possible application of their data to a commercial cell. In the latter case, of course, the anode would not be platinum and the reaction could not be so perfect, but an idea would be obtained of the maximum amount of sulfur dioxide per commercial unit that could be possibly oxidized under given conditions.

Multiplying current density by current efficiency by the factor 1.192 (which is the grams sulfur dioxide

oxidized per ampere-hour when this is the sole reaction) gives at once the weight in grams of sulfur dioxide completely oxidized to sulfuric acid per square decimeter of anode surface per hour, for any given experiment. The resulting figure is a measure of the absorption yield of sulfur dioxide or the production yield of sulfuric acid or the relative velocity of the desired anode reaction, according to the view-point. It could be applied at once to any commercial cell unit of given size. The shape of the curve would evidently be the same as that of the current efficiency curves as given by Messrs. Thompson.

The current efficiencies obtained in the investigation seem remarkably good. Under such conditions the depolarizing effect would seem to be at its maximum and indeed in the case of 10 per cent sulfuric acid no anode oxygen was evolved at all even with very considerable current densities. At first glance, it might seem that the anomalous condition prevailed of perfect absorption with no depolarizing effect, as the cell voltage was 4.00 for 10 per cent sulfuric acid and a current density of 19 amperes per square decimeter (the presence of the porous cup diaphragm and the extra resistance thereby introduced into the circuit is kept in mind). However, 19 amperes per square decimeter is 176 amperes per square foot, an extremely high density when compared with metal deposition practice, where current densities commonly range between 10 and 40 amperes per square foot. Any depolarizing effect is therefore masked by the high electrolytic resistance drop and Messrs. Thompson's figures on cell voltage can hardly be discussed without further information from them. Comment on any depolarization observed and on this phase of the subject in general would be extremely interesting.

Apropos of a sulfur dioxide anode, several years ago the writer directed an investigation of a sulfur dioxide-platinum black anode immersed in a solution of copper sulfate, sulfurous and sulfuric acids. On open circuit the single potential was found to be $+0.42$ volts (electrode positive to the solution; here as elsewhere the sign refers to the charge on the electrode). A normal calomel electrode assumed to be $+0.56$ volts was used in making the measurements. A copper cathode in the same solution had a single potential of $+0.54$. The open circuit combined cell voltage was therefore only $0.54 - 0.42$, or 0.12 volts, a figure that looked extremely promising.

Sad to relate, on applying something like a commercial current density to the cell, about 30 amperes per square foot at the anode and 15 at the cathode, the sulfur dioxide electrode "broke down" completely, even changing its sign, becoming -1.10 volts. The copper cathode went to $+0.70$, so that the cell voltage at the electrodes was $1.10 + 0.70$, or 1.80 volts. The electrodes were spaced 1.5 in. between surfaces and with the strength of solution used the total electrolytic resistance drop amounted to 0.55 volts. The external cell voltage under running conditions was therefore $1.80 + 0.55$, or 2.35 volts total, instead of the approximately 0.7 volts that we had hoped for. Some sulfurous acid was oxidized to sulfuric but the reaction seemed too slow to appreciably depolarize the cell or to promise any practical advantages. That using still higher current densities might have caused any improvement in the matter did not occur to anyone at the time and the investigation was therefore dropped as leading to negative results. It was made with some care and using delicate instruments, but not under exactly research conditions or using pure materials.

The writer has ever after been somewhat skeptical of the commercial utility of using sulfur dioxide as an anode depolarizer when electrolyzing copper sulfate solu-

tions with insoluble anodes. However, some very broad claims have been made in the past, even down to running cells with no more energy consumption than in the case of soluble anodes. Of course catalytic agents in the solution, iron, etc., have a large effect on the oxidation of sulfur dioxide at the anode and would help to give the result desired. Still, it would be interesting to learn of a single running plant at the present time where depolarization with sulfur dioxide is being satisfactorily used on a commercial scale.

MAURICE R. THOMPSON.

General Electric Co.,
Power and Mining Department,
Schenectady, N. Y.

* * *

To the Editor of Metallurgical & Chemical Engineering

SIR:—Replying to Mr. M. R. Thompson's comments on the article by Mr. N. J. Thompson and myself, I would say that the high voltage found necessary to get the currents desired was due partly to the diaphragm and to the polarization of the hydrogen liberated. On account of lack of time, no single potential measurements of the anode were made. These, of course, are important and it is hoped to add them later. It would appear from the measurements of your correspondent that there is a resistance to the oxidation of sulfurous acid similar to that observed by Haber and Russ in the case of hydroquinone (*Z. f. phys. Chem.* 47, 257, 1904).

M. DEKAY THOMPSON.

Massachusetts Institute of Technology,
Cambridge, Mass.

More Publicity Urged on Industrial Research Laboratories

To the Editor of Metallurgical & Chemical Engineering

SIR:—The undersigned Committee on Engineering of the General Committee on Research of the American Association for the Advancement of Science feels that it is timely to issue the following appeal to the industrial research laboratories of the country.

In the course of work done in the numerous industrial laboratories of America, many physical and commercial constants and data of great scientific interest and value are doubtless arrived at, and which may, for a certain period of time, constitute an asset of considerable commercial value to the particular corporations in question. During this period, everyone recognizes the proprietary right of the industrial laboratories to the retention of this information.

A time frequently arrives, however, when such scientific information loses its commercial value (often by being duplicated in other laboratories), and just at this point we wish to impress upon the industries their obligation to enrich scientific literature with such facts and data, which might otherwise be lost or forgotten.

Some of our industries have been reproached with the suspicion of acting as sponges, in that they absorb an immense amount of useful information from scientific literature without giving any return in kind. This suspicion would be entirely removed if, from time to time, scientific information which has ceased to be of commercial value were contributed by them to its appropriate channel and thus became available to all scientific workers throughout the world.

If any doubt exists as to the appropriate channel for the publication of such scientific data and communications, the secretary of the A. A. S., Dr. J. McKeen Cattell, Garrison-on-Hudson, New York, will be glad to act as intermediary and to forward such communications to the proper scientific body.

A. E. KENNELLY, J. W. RICHARDS, A. SAUVEUR, A. N. TALBOT, C. C. THOMAS.

Who ?

From the "Transactions" of the Buffalo Section, Institute of Literary Engineers.

Who takes the pleasure out of life and makes existence Hell?

Who fires a real good-looking one because she cannot spell?

Who substitutes a dictaphone for coral-tinted ear?

The penny-chasing, dollar-wasting efficiency engineer!

Coming Meetings and Events

American Institute of Mining Engineers, annual meeting, New York, Feb. 19-22, 1917.

American Chemical Society, New York Section, Nichols Medal Award, Chemists' Club, New York, March 9, 1917.

American Chemical Society, spring meeting, Kansas City, Mo., week of April 9, 1917.

American Electrochemical Society, spring meeting, Detroit, Mich., May 2-5, 1917.

American Electrochemical Society, autumn meeting, Pittsburgh, Oct. 3-6, 1917.

National Safety Council Broadening Its Activities

The National Safety Council, the leading accident prevention agency in the country, is broadening its activities, and has commenced monthly publication of a series of safe practices leaflets. The council has a committee of fifty safety experts working out the maximum and minimum requirements in safeguarding, and has already issued three leaflets on this important work. These are entitled respectively "Ladders," "Stairs and Stairways" and "Boiler Rooms." Others will be issued monthly.

The purpose and scope of these leaflets is explained in a preliminary announcement in the leaflet on "Ladders" as follows:

"The National Safety Council was established to help free mankind from accidents, and, to that end, to gather to itself as members all those concerned and interested in the safety movement, and to bring about an understanding of accident causes and find and apply remedial measures.

"The field has been new and the various services rendered have met the need, in so far as the council's modest income from its nominal fees, its experience and the experience of its members have permitted. The time has now come when the pioneering period has partially passed and our accumulated experiences permit, and the awakening needs require, that the great amount of collected and obtainable safety information be put into concrete and popular form for the benefit of the cause.

"The executive committee has, therefore, decided to compile the best information obtainable about safe practices of all kinds and to present same in a logical and orderly form. It is hoped it will become an encyclopedia of information on all phases of the subject. It is fully realized that this is a very large undertaking, but this need not deter us if the accomplishment is necessary to the progress of the council's purpose and its service to its members. The council will simply do the best it can with such a large and important subject, relying upon the co-operation of the members for the success of the plan.

"The gathering and compiling of data will have to be sectionalized to cover the field."

The organization includes in its membership many of the leading industrial concerns of the country, and

has offices in the Continental & Commercial Bank Building, Chicago. Mr. W. H. Cameron is general manager.

Award of the Elliott Cresson Medal to E. F. Northrup

The Franklin Institute has recently awarded its Elliott Cresson Gold Medal to Edwin Fitch Northrup, Ph.D., research physicist, of Princeton, N. J.

This award was made in recognition of a special type of electric furnace developed by Dr. Northrup, in which a temperature of more than 3000 deg. C. can be developed, and of his pyrometric methods and new pyrometric apparatus for the direct and accurate reading of high temperatures up to 1600 or 1700 deg. C. Means are provided whereby, with a slight modification in the pyrometric apparatus, rapid measurements can be made of the resistivities of many molten metals and other liquid materials through a wide range of temperature.

The Western Metallurgical Field Shale Oil

Experimental Plant for the Extraction of Oil from Shale for Flotation.—After a lengthy and careful investigation as to the suitability of oils extracted from Colorado shale for flotation, the Oil Shale Mining Company of Colorado has decided to install an experimental plant for the extraction of the oil near De Beque, Mesa County, Colorado. Endeavors are being

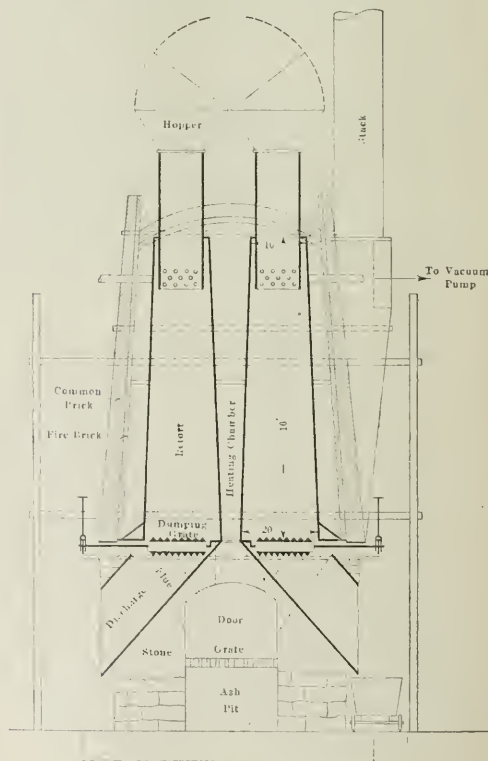


FIG. 1—RETORTS USED IN THE DISTILLATION OF OIL FROM SHALE

made to have the necessary apparatus ready for shipment by the beginning of March.

The initial plant unit will consist of six retorts, similar to the Henderson type, in successful use in Scotland, where the shale oil industry has been in operation for more than fifty years. The retorts are made of cast iron and are 16 ft. in height, tapering from 20 in. at the bottom to 16 in. at the top. At the bottom of each retort is a grate, through which the cinders are removed to a discharge. Near the upper end of each retort is an exhaust, connected with a low vacuum pump, which draws off the volatile vapors which are to be condensed. The retorts are charged from the top through hoppers, which are kept closed during operations. The heating is done from the outside. A grate at the bottom of the chambers surrounding the retorts supports the fuel bed. The products of combustion impart their heat to the retorts and the charge, and then go to the stack. The heating chamber is made of common brick lined on the inside with a layer of firebrick. The retorts are placed in two rows of three each. Fig. 1 shows a vertical section through the apparatus.

The shale, suitably crushed, is fed through the hoppers into the retorts and subjected to distillation under diminished pressure. The vapors are withdrawn through the exhaust near the top of the retort, and are condensed by passing through a metal coil immersed in cold water. No efforts are being made at the present time to fractionate the oil, as the demand of the product for flotation processes is such that the company is looking toward the money made by these sales to defray the expenses of any further experimental work.

It is claimed that the oil thus obtained is a good frothing agent, and does not become as viscid as coal-tar oils when used in connection with cool water under identical conditions. It is estimated that the unit as constructed will yield 20 bbl. of oil per day at 42 gal. to the barrel. The market value per barrel will range from \$4.50 to \$6. A ready market for the output is claimed by the company.

Company Reports

Annual Report of The Granby Consolidated Mining, Smelting and Power Company, Ltd., Ending June 30, 1916.—During the fiscal year the production of the various plants connected with the company from 1,897,251 tons of ore treated was 42,198,083 lb. of copper, 487,845 oz. of silver and 44,848 oz. of gold. At the Anxox Smelter, Anxox, B. C., three furnaces were operated on green ore, while a fourth was used for regrading matte. The tons of ore per furnace day increased from 630 to 692 and the tons of charge from 846 to 929. The cost of smelting and converting was \$1,804 per ton of ore, or \$0.073 less than for the previous year. The amount of ore treated at this plant was 822,919 tons, yielding 29,562,177 lb. of copper. The Anaconda charging system was installed during the course of the year, and the shaft depth of No. 4 furnace was increased by 5 ft. for experimental purposes. The latter change proved so satisfactory that any new furnaces will be built on the same type.

The Grand Forks Smelter handles approximately 500,000 tons of low-grade copper material high in silica. Eight furnaces were in blast. Up to the present time this material was not taken in the ore reserves, but on account of the high price of copper which prevailed during the past year the handling of this material became profitable. For the first six months of the year the cost of smelting and converting was \$1,233 per ton. The plant also converted 21,428 tons of matte from the Anxox smelter.

Philadelphia Hearing in Miami Flotation Suit Before Court of Appeals

The hearing of the Minerals Separation vs. Miami Copper Company infringement suit commenced before the United States Court of Appeals for the Third Circuit in Philadelphia on Tuesday, Jan. 30, and continued until the following Saturday noon.

In the lower court, the United States District Court for the District of Delaware, Judge Bradford had rendered the opinion that the principal patent, 835,120, for a fraction of 1 per cent of oil in its principal claims, was valid and infringed; also that the patent 962,678, for soluble frothing agents was, in the claims under consideration, valid and infringed, but that the third patent in suit, 1,099,699, for aromatic hydroxyl frothing agents without acid and in the cold, was invalid (*Met. & Chem. Eng'g.*, Oct. 15, 1916, Vol. XV., pages 433 and 441).

The appeal was therefore a cross appeal; the Minerals Separation appealed from Judge Bradford's finding as to the third patent in suit, while the defendant in the lower court, the Miami Copper Company, appealed on the other hand as to the findings on the first and second patents in suit.

Judge Bradford in his opinion had stated that the reduction of oil in patent 835,120 was so great as compared with the amount of oil used in prior-art processes as in itself to constitute invention—that is, that the reduction of oil *per se* was patentable. This was at variance with the law finding of the Court of Appeals in San Francisco which had maintained in the Hyde case that the mere reduction of oil was not patentable and had found upon matters of fact that there being only a difference of oil, patent 835,120, was invalid.

In the Supreme Court of the United States the patent 835,120 was found to be valid, this decision following Judge Bradford's by only a few weeks.

This condition then left the case before the Circuit Court of Appeals in the Third Circuit (the Miami case) with two main contentions.

There was a difference of opinion as to what the interpretation of the Supreme Court decision really should be.

The Miami attorneys claimed that the Supreme Court had in its decision affirming the validity of the patent definitely limited the patent to a fraction of 1 per cent of "oil" in combination with a novel agitation, greater than previously used, by "beating in" air, and with the formation of a characteristic "froth," different from any heretofore produced.

Under this construction the decision of the United States Supreme Court was at variance with that of Judge Bradford and in harmony with the Court of Appeals of the Ninth Circuit, as to law, but at variance with the Ninth Circuit as to fact.

The pith of the question before the court as to infringement or otherwise therefore, was largely dependent upon the manner of interpretation of the Supreme Court decision in the Hyde case. In the discussion and for illumination of this, various prior-art processes were considered and experiments shown.

Preliminary to the arguments the court requested each side to present "a skeleton" of their respective cases, so that the court might then more understandingly follow the arguments.

After this each claim was taken up separately and the Miami attorneys stated what part of each claim they acknowledged as used in the operation of their process and what part they denied. For example, "ore pulp"—"admitted"; "small quantity of oil, fraction of 1 per cent"—"admitted"; "agitation to produce a froth"—

"denied"; "and remove the froth"—"denied," etc. Thus through each claim was analyzed.

The judges sitting were Judges Buffington, MacPherson and Wolley. The argument on behalf of Minerals Separation was made by Mr. Henry D. Williams and the closing by Mr. Wm. H. Kenyon; for the Miami Copper Company the argument was made by Mr. Louis Marshall and Mr. W. A. Scott, and the closing by Judge George Gray of Wilmington, Del. The latter had previously sat upon the very bench he was addressing, and with two of the judges now on the bench, Judges Buffington and MacPherson.

As in the court demonstrations in Wilmington, illustrative of the prior art, there was a wide discrepancy as to the interpretation of the disclosures. (See *Metallurgical and Chemical Engineering*, July, 1915, Vol. XIII, page 409.)

There was also an important difference in this court in the experimental illustration of the Miami Copper Company's process.

The Minerals Separation experts agitating the pulp violently in "Gabbetts," which they stated represented a centrifugal pump and Pachuca tank in the Miami initial plant, whereas the Miami experts very gently mixed the pulp and oil and then introduced to the canvass-bottom cell and the spiral coil apparatus of prior patent 793,808, which process Judge Bradford had stated in his decision was the process of the Miami Copper Company. The Minerals Separation experts obtained their air for the cell from compressed-air cylinders at 200 or 300-lb. pressure, admitted to the cell through reducing-pressure valves, which psychologically at least impressed the court with the idea that the air was "shot into" the pulp—an impression which seemed to be dispelled when the court witnessed the Miami company's experimental illustration of their process.

Judge Gray made the closing argument for the Miami company. He dwelt upon the limiting conditions imposed by the United States Supreme Court as to novel violence of agitation and characteristic permanence of froth, contending that to broaden the patent 835,120, so as to cover the operations of the Miami Copper Company's process would in effect be to reincorporate the original claim 12, which the U. S. Patent Office had denied, and which patentees had withdrawn, a claim in which the terms "agitate to produce a froth" had not been used.

Mr. Kenyon made the closing argument for the Minerals Separation, contending that the apparent limiting clauses in the Supreme Court's decision were part of the description, not of the decree, and that the "short step" referred to was the step "turning failure into success," and that the patent was, therefore, in effect "a master patent" if not actually the pioneer patent.

Chemical and Electrical Porcelain

The "Chemical and Electrical Porcelain" meeting held jointly by the New York Section of the American Electrochemical Society, American Chemical Society and Society of Chemical Industry on Friday evening, Feb. 9, was very well attended and the papers were very interesting. Dr. COLIN G. FINK presided as chairman of the New York Section of the American Electrochemical Society which had made the arrangements for the meeting. The international situation has made us dependent on domestic sources for porcelain and, as in many other lines, the manufacture of this commodity is commanding a great deal of attention. This is especially true for chemical porcelain for which we were formerly dependent on foreign sources of supply.

Dr. CHARLES F. BINNS, of Alfred, N. Y., director of the New York State School of Clay Working and Ceramics, at Alfred, gave an interesting illustrated talk on the history, constitution and manufacture of porcelain, showing some microphotographs which brought out many interesting points. The various furnaces and other apparatus used were also described. Dr. Binns has devoted a life-time to the subject of ceramics and did not think the volume of American business in chemical porcelain would warrant a separate factory for its manufacture, although we have the raw materials and everything necessary for its manufacture, if the proper technique is observed. He also thought that protection was necessary to protect the industry from foreign competition after the war.

Mr. L. E. BARRINGER, president of the American Ceramic Society and chief engineer of insulation of the General Electric Company, gave an interesting account of the manufacture and properties of porcelain for electrical insulation, supplementing his remarks with lantern slides. He showed several pieces of porcelain ware made by the dry process for low voltages and by the wet process for high voltages. One of the interesting features of his talk was the description of a continuous kiln fired in the center with the material going in at one end, gradually approaching the hot center zone and being drawn out at the cool end. This kiln saves 50 to 60 per cent of the heat used in an intermittent kiln.

Dr. A. V. BLEININGER, of the Bureau of Standards, Pittsburgh, Pa., took up a discussion of the physical and chemical characteristics of porcelain, explaining the effect of the various constituents on the final product. The Bureau of Standards has done a great deal of work in the study of porcelain, which is of great value to our manufacturers.

In the discussion Dr. W. D. Bancroft, of Cornell University, suggested that straight sillimanite would be an interesting product to study, not so much from commercial considerations but from a theoretical standpoint. Dr. Bleininger said the potential difficulties were very great in producing this. Mr. R. C. Schroth, Jr., president of the Laboratory Supply Company, Columbus, Ohio, agents for the Ohio Pottery Company, said this company had conducted considerable research in the last two years and that they were firing at the high temperatures used abroad. Several samples of this company's chemical porcelain were on exhibit.

Methyl Alcohol and Acetone as By-Products of the Soda Pulp Industry*

By Alfred H. White and John D. Rue

The introduction of lime as an agent for the disintegration of straw for paper-making is attributed to the Chinese, and the process was in use in Europe in the seventeenth century. The use of caustic soda under pressure for the manufacture of pulp from straw was introduced by M. A. C. Mellier, of Paris, who took out a French patent in 1854 and United States patent 17,387 in 1857. The real development of the woodpulp industry came in America, although based on patents of Watt and Burgess, of London, who in 1853 took out an English patent, and in 1854 an American patent, 11,343, whose rights were assigned to Messrs. Ladd and Keen, of New York.

The first plants for the operation of their process seem to have been erected at Royers Ford, Pa., and later at Manayunk, near Philadelphia, by the American Wood Paper Company.

*Read at the annual meeting of the Technical Association of the Pulp and Paper Industry, New York, February 7, 1917.

The American practice early differentiated itself from European by the use of more concentrated caustic liquors, so that the recovery of the soda by evaporation of the black liquors and incineration of the residue was a feature of the process almost from its infancy in this country. The attempts made in Germany and Scandinavia to cook with weak liquors which might be wasted were not commercially successful, and the American system was introduced into Europe soon after 1870. After its introduction the Germans made important improvements in methods of washing the pulp, concentrating the black liquor and calcining the soda.

The system of alkali recovery in the early mills was copied somewhat from the Leblanc soda process. The liquor was concentrated in a series of pans heated by direct fire, and the liquor passed from pan to pan, approaching nearer the fire each time. The thick mass was finally calcined in an open pan. Attempts to still further utilize the heat of the gases from the calcining furnace led to the construction of towers through which the dilute black liquor fell in a spray or tumbled down over a series of shelves against the flow of the hot gases.

The introduction of the multiple effect evaporator marked an important step in the industry. The evaporator was what is now the well known Yaryan type, invented by Homer T. Yaryan of Toledo, Ohio, in 1886. It was developed and adapted to the concentration of waste liquors from the soda mills by Augustus G. Paine of New York, who in 1890 consolidated several mills under the name of the New York and Pennsylvania Company. To this same company is due the introduction of the rotary kilns for burning the concentrated black liquor. A patent on this feature taken out by L. D. Armstrong of the company in 1892 (U. S. Patent 480,702), and patents were also taken out by S. D. Warren & Co. of Boston, Mass. The commercial problem was worked out by the two companies in collaboration, and the type of rotary then developed is still in general use in soda pulp mills. The organic material in the concentrated liquor is nearly sufficient to complete the evaporation and maintain the required amount of combustion. Some of the waste heat is used to generate steam in boilers set into the flues. No attempt is made in the present process to recover any valuable product but the alkali.

Our own interest in this subject has been in trying to recover methyl alcohol and acetone by destructive distillation of the black liquors. We have been assisted in this both in the laboratory study and in the tests on the larger scale by the New York and Pennsylvania Company, to whom we wish to express our thanks. Our acknowledgments are especially due to Mr. George K. Spence and Mr. John Krauss, chemists at the Clarion mill, for their unfailing courtesy and assistance.

THEORETICAL

The process of destructive distillation of wood to produce methyl alcohol, acetic acid and charcoal is an old one. The question as to the constituents of the wood which produced these products has, however, had little study. Klason¹ has pointed out that the alcohol must come from the lignin, since the destructive distillation of cellulose gave no alcohol in his tests. We have in the main confirmed his results since the destruction distillation of soda pulp, which is not entirely free from lignin, gave in our tests only 0.06 per cent by weight of methyl alcohol, while hardwood pulp chips gave 1.47 per cent by weight. It is therefore evident that the material of the wood which produced the alcohol went into solution in the soda digester or was decomposed entirely and evolved as gas.

Indirect evidence is afforded by the tests of Bergström and Fagerland², who determined the amount of methyl alcohol evolved with the gases given off during a sulphate cook and found that 1.3 per cent on the weight of the pulp, or perhaps 0.65 per cent on the weight of the wood, was converted into alcohol during the cooking process.

The total methoxy groups in the wood as determined by digestion with strong hydriodic acid is frequently assumed to give the maximum amount of methyl alcohol which can be obtained from a given substance. Benedikt and Bamberger³ tested wood in this way and obtained indicated maximum yields of methyl alcohol varying from 4.38 to 6.52 per cent by weight of the wood, according to the species. This figure is so large that it is evident that there must still be possibilities for considerable alcohol recovery from the waste liquors. Streeb⁴ showed that the methoxy content of the lignin acids precipitated from black liquors by mineral acids was between 5.78 and 5.98 per cent. Attempts were made by H. Lowe in 1861 and Tessie du Motay in 1871 to precipitate the organic matter by carbon dioxide to facilitate the recovery of the waste lyes, but their results were not commercially successful. Rinman⁵ has patented a process similar to this involving precipitation of the humus matter by carbon dioxide or stack gases and destructive distillation of the solid residues. Our own experiments have shown that lignin from hard wood precipitated in this way gives on destructive distillation 1.62 to 2.20 per cent by weight combined alcohol and acetone, which is only about two-thirds as much as an equivalent amount of highly concentrated black liquor gives when distilled under the same circumstances.

LABORATORY TESTS

Attempts to distill this concentrated black liquor by heating the full charge in a still such as might be used for tar gave much trouble. The liquor foamed badly and after the destructive distillation was started an exothermic reaction developed which caused a violent evolution of gases. The process of feeding the liquor gradually into an inclined preheated retort gave much better results. In this way successive films of the liquor were subjected to distillation at an even temperature. Not only could the temperature be controlled, but also the length of time which the vapors remained in the hot retort and the extent of the contact with the charcoal, which latter agent has been shown to have a powerful catalytic effect. Experiments showed that the best results were obtained at temperatures even lower than those usual in wood distillation, provided an adequate time was allowed. The temperature of 550 to 600 deg. Fahr. (288 to 316 deg. C.) seemed most desirable.

The laboratory retort used for these tests was made from a piece of gas pipe 3 in. in diameter and 18 in. long which was set in an inclined position. The liquor entered continuously through a side arm at the middle of the retort and the gases left at the upper end. The results of a series of seven consecutive tests with this retort on liquor averaging 41.3 deg. B. are given in Table I. The average result of the seven tests shows 3.81 per cent by volume of methyl alcohol and 0.56 per cent by volume of acetone in the aqueous distillate. Five of the tests are on liquors from hard wood, mostly beech, and two are from the soft wood, mainly bass wood. It is noteworthy that this soft wood which, if distilled directly, would yield very little alcohol, gives fully as good results after the soda treatment as does the hard wood. Other tests on popular and jackpine liquors have shown

¹Papier-Fabrikant, 7, 27-32, 78-82, 104-6, 129-31 (1909); 8, 970-1, Monatshefte, 11, 260-7, 1890.

²Dissertation Göttingen, 1892.

³Papier-Fabrikant, 10, 39-41, 101-4, 1912; 12, 212-5, 1914.

⁴Ztr. f. angewandte Chem., 23, 1252-7, 1910.

good yields of methyl alcohol, though the conditions necessary for the best results have not been worked out.

In this series of Table I the rate of feeding was such that the vapors stayed in the retort from 15 to 30 seconds. Under these circumstances the liquor as it entered the retort foamed and was charred almost immediately, so that the whole interior space of the retort became speedily filled with a very porous black ash which offered a very large amount of contact surface. In some tests the upper part of the retort was filled prior to the test with a wire basket containing black ash, to give more contact surface. This did not seem to be neces-

TABLE I—LABORATORY DISTILLATIONS OF BLACK LIQUOR FROM SODA PROCESS IN RETORT MADE FROM 3-INCH IRON PIPE

Test No.	Specific Gravity of Liquor in Degrees Be	Kind of Wood	Volume Per Cent of Aqueous Distillate	COMPOSITION OF A JUGS OF DISTILLATE, PER CENT BY VOLUME		Average Retort Temperature, Degrees F.
				Methyl Alcohol	Acetone	
5	40.4	Hard	66.0	4.03	0.45	513
6	40.4	Hard	61.0	3.64	0.18	548
7	40.4	Hard	67.0	3.48	0.67	596
8	41.0	Hard	65.4	3.47	0.69	573
9	41.0	Hard	67.5	3.73	0.53	567
10	43.0	Soft	67.6	4.57	0.67	567
11	43.0	Soft	64.0	4.06	0.66	615
Aver.	41.3		65.5	3.81	0.56	

sary at the higher temperatures but did give better results at the lower temperatures. Test Number 3, of this series was distilled at a temperature of 555 deg. Fahr., which was entirely satisfactory in other cases, but in this test the liquor was fed at a rapid rate so that the gases stayed in the retort only eight seconds, as against the fifteen or thirty seconds of the other tests. In this test the destructive distillation was complete, as shown by the well charred black ash, but the combination of low temperature and short time showed its effect in the large volume of distillate, 76.0 per cent by volume, and the low yield of alcohol and acetone, which together amounted to only 1.96 per cent by volume of the distillate, whereas the average of the other tests gave 4.37 per cent.

LARGE SCALE TESTS

It was evident from the laboratory tests that in order to obtain good yields of alcohol and acetone it was advisable to conduct the distillation rather slowly and at a temperature well below a red heat and not necessarily above 550 deg. Fahr. This temperature is no higher than that of the waste gases from many steam boilers and made it evident that steel could be safely used as the retort material. The greatest practical difficulty in transferring the process to a large scale came from the rubbery nature of the product during the initial stages of the treatment. Starting as a thick syrup at 40 to 42 deg. B., it changes as the water is driven off to a mass which is sticky and plastic while hot and tough and hard while cold. It also foams strongly during the first stages of the destructive distillation.

The two previous experimenters who have recorded their work in this field have both emphasized the difficulties in handling this material. Meyer⁴ proposes to absorb the thick syrup in briquettes of charcoal previous to the distillation, and Sandberg⁵ uses a combination of mechanical scrapers and screw conveyors to work the material through the retorts. The authors have found it preferable to allow the liquid to flow as a film over the inside of the retort and build up an increasing thickness of charcoal, and then discharge the retort altogether and start afresh.

Both vertical and inclined retorts have been tested. The vertical retort was rectangular, 12 by 18 in. in cross section and 10 ft. in height above the grate bars. The top was closed by a lid in a liquor seal that also served as the means of introducing the liquor which trickled over the edge of the retort and ran down the sides, charring as it went. It was found, however, that the liquor ran down the hot sides of the retort so rapidly that it reached the bottom while still liquid and collected in a pool at the bottom of the retort. The catalytic effect of the carbon was also much less in this large retort than in the laboratory retort, so that the best results were obtained when the vapors stayed in the retort 75 seconds instead of the 15 to 30 seconds necessary with the smaller retort. Even under these conditions the yields were only about 60 per cent as much as those with the smaller retort.

The next attempt was to use an inclined retort which was merely the laboratory retort on an enlarged scale. After preliminary tests to determine the proper angle a battery of twenty-four retorts was constructed. Each retort was made from steel well casing 9.6 in. in diameter and 12 ft. long set with the upper end 3 ft. higher than the lower. This bench was operated twenty-four hours a day for three weeks without any serious operating troubles. The black ash was well charred and leached to a colorless solution, leaving a soft and porous charcoal. There was absolutely no volatilization of soda ash from the retorts, showing that the loss of soda from the rotaries could be entirely eliminated. The doors of the retorts were not properly made and could not be closed tightly. If suction was kept on the retort air leaked in and destroyed some of the products. If there was back pressure on the retorts the gases leaked out and some of the distillate was lost. An inadequate condenser also caused loss. Because of these defective details the average results were lower than they should have been.

For short periods of time as good results could be obtained as on the laboratory scale but, as the average of a day's run, the strongest distillate obtained was when 439 gal. of 40.1 deg. B. liquor from bass wood were distilled and gave a distillate containing 2.75 per cent by volume of methyl alcohol and 0.46 per cent acetone, which is about 75 per cent of the strength obtained on the laboratory scale. There does not seem any reason to doubt that, with leaks eliminated, this apparatus could give results in every way as good as those obtained in the laboratory. The capacity of this plant was 1 gal. of concentrated liquor per retort per hour or 576 gal. per day of twenty-four hours for the unit installed. It was an experimental plant with the feeding of the liquor and discharge of the black ash controlled by hand, which made the labor cost altogether too high for commercial operation. The chief problem still remaining is that of designing efficient machines for replacing hand labor in these operations.

In this particular installation natural gas was burned, but tests for several successive days showed that the black ash as it came from the retort could be completely burned on grates below the retorts, fused white soda ash dripping through the grate and collecting as stalagmites in the pit below. This procedure is not, however, wholly advantageous, since there is loss of soda mechanically carried off with the smoke gases just as there is from the rotaries. Better practice would involve leaching the black ash as usual and then burning the leached wet carbon in gas producers or, after drying by waste heat, burning it directly on grates or in the form of powdered fuel.

The yields to be obtained from the destructive distillation are shown in Table II, calculated to a basis of 1000 gal. of 40 deg. liquor and also to a basis of a cord of

⁴U. S. P. 407, 442 July 23, 1888
British patent 23,125 of 1912

wood. The figures given are really for hard wood, but the yields from soft wood per 1000 gal. of black liquor are practically the same and the yields per cord of soft wood need to be corrected only for the difference in the weight per cord to make them approximately accurate. The yields of methyl alcohol and acetone are all based on analyses of the distillates, since no refining tests on the large scale have been made. No difficulties in the refining process, however, have been indicated by the

TABLE II—YIELDS FROM DESTRUCTIVE DISTILLATION OF CONCENTRATED BLACK LIQUORS FROM SODA PULP PROCESS

Composition of black liquors of 40° B _e :		
	Percentage by Weight	Pounds per 1,000 Gals.
Water	31.7	3,640
Organic matter	40.0	1,600
Ash	28.3	3,260
	100.0	11,500

Yields from 1,000 gals. Black Liquor of 40° B _e :			
	Percentage by Weight	Pounds	Gallons
Aqueous distillate	41.6	4,790	575
Tar	5.9	650	71
Black ash	44.5	5,120	...
Gas (by diff.)	8.3	940	...
	100.0	11,500	...

Carbon after leaching Black Ash 2100

Black Ash Composition:		From Hard Wood, Per Cent	From Soft Wood, Per Cent
Combustible	41.3	44.3	44.3
Ash	58.7	55.7	55.7

Aqueous Distillate:			
		YIELD FROM 1,000 GALLONS 40° LIQUOR	
		Percentage Composition	
		Pounds	Gallons
Methyl alcohol	3.81 by vol.	145.0	21.9
Acetone	0.56 by vol.	21.6	3.2
Ammonia (as NH ₃)	0.04 by wt.	4.6	.....

Yields per Cord of Wood put into Digesters:

Based on 890 pounds of soda ash per cord of wood weighing when chipped 44,100 pounds 890 pounds of soda ash are found in 273 gallons of 40° liquor.

273 gals. 40° liquor yield 157 gals. aqueous distillate, containing:

6.0 gals. methyl alcohol 100 per cent.
.9 gals. acetone
6.9 gals. alcohol and acetone.

laboratory distillations. The distillate contains no acid and therefore iron condensers and stills may everywhere replace the more expensive copper. Neither is there any need of the expensive first distillation of the entire liquor which the wood distillers must make to separate the acetic acid from the tar. The liquor as it comes from the tar separating tanks is practically in the same stage as that from the wood distillation after the first distillation has been completed and the acetic acid has been neutralized.

TAR

The tar forms about 11 per cent by volume of the total distillate from hard wood. It has a specific gravity of 1.10 and a pungent odor entirely different from that of either wood tar or coal tar. On distillation, according to the method of Church,¹ it gave the following results:

Journ. Ind. and Eng. Chem., 3, 227-233, 1911; 5, 195-6, 1913.		Per Cent
Water	8.6	8.6
Oil below 100 deg. C	1.7	1.7
Oil 100-205 deg. C	5.4	5.4
Oil 205-270 deg. C	47.3	47.3
Soft pitch	35.9	35.9
Total	98.9	98.9

It contains nearly 50 per cent of distillable phenols, the fraction from 205 to 270 deg. C. being composed of phenols to the extent of 80 per cent. On mixing with formaldehyde and an alkali, this fraction polymerizes to a plastic substance even in the cold and on heating it yields a solid body. The tar is an interesting material, but its value is as yet entirely unproven.

ALCOHOL IN STEAM FROM SODA DIGESTERS

A small pipe with a condenser was connected to the relief line from one of the digesters, and a portion of the steam allowed to blow off during the cook was condensed and tested for alcohol and acetone, with the following results:

Composition of Condensate from Soda Digester

A—Using Hard Wood

Steam on at 11:30 A.M.

Up to 115 lb. pressure and relief valve opened at 1:15 P.M.

Hourly Sample	PER CENT BY VOLUME		Per Cent by Weight Ammonia (NH ₃)
	Methyl Alcohol	Acetone	
1	1.00	0.02	...
2	1.48	0.06	...
3	1.43	0.07	...
4	1.37	0.07	...
5	1.35	0.09	...
Average	1.32	0.06	0.06

B—Using Bass Wood.

Steam on at 6:50 A.M.

Relief valve opened at 8:40 A.M.

Hourly Sample	PER CENT BY VOLUME		Per Cent by Weight Ammonia (NH ₃)
	Methyl Alcohol	Acetone	
1	0.62	0.03	0.026
2	0.80	0.04	0.026
3	0.44	0.04	0.023
4	0.39	0.04	0.021
Average	0.61	0.04	0.024

It was not feasible to measure the steam given off from each digester, but it was estimated at 145 gal. per digester. This would indicate a loss of about 2 gal. of alcohol and acetone from each digester of hard wood and about half that from each digester of bass wood. It did not seem feasible to condense any of the steam from the charge as it was dumped, but that given off immediately after the digester was discharged would undoubtedly have contained as much alcohol as that from the last sample during the cook. The amount of ammonia formed (0.06 per cent) is small but interesting. The values indicated here are too small to warrant recovery in an independent plant, but would probably be worth recovering as a side issue in a plant equipped for destructive distillation of the black liquors.

COST OF OPERATION AND RETURN

The process discussed here merely replaces the rotary calciners by suitable retorts operating at temperatures well below a red heat. The multiple effect evaporators before the process and the leaches after the process need not be changed. The question concerns the cost of installation and operation of the retorts, condensers, etc., as compared with the rotary calciners. No fuel need be purchased to heat the retort since the carbon from the black ash will provide the necessary heat. One thousand gallons of 40 deg. black liquor contain only 3640 lb. of water and yield 2100 lb. of carbon after leaching which is in the ratio of 1.74 lb. of water per pound of carbon. The destructive distillation evolves heat so that the only work which the fuel has to perform is to heat the material to 600 deg. Fahr. and to vaporize the water. The

temperature of the stack gases is as low as that of the average steam boiler and on a basis of steam boiler performance a half of the carbon should be sufficient to heat the retorts and supply sufficient waste heat to dry the leached carbon in waste heat driers. It is therefore conservative to assume that if the carbon is not more valuable for other purposes it will be sufficient to cover all fuel requirements of the plant.

The absence of acid from the distillate makes it unnecessary to use copper in the condensers or stills and also eliminates the necessity for the complete distillation with high pressure steam or in vacuum to separate the acetic acid from the tar. The steam requirements

TABLE III—ESTIMATED COST OF OPERATION AND RETURNS FROM BY-PRODUCT PLANT BASED ON ONE CORD OF WOOD COOKED IN SODA DIGESTER

To be Credited to By-Product Plant per cord of wood:		
6.9 gallons 95 per cent methyl alcohol and acetone @ \$1.10	\$3.76	
41.5 lb soda ash (5 per cent of total, now lost in stack gases)	0.44	
570.0 lb carbon counted here only as fuel		
Saved by elimination of present rotary kilns	0.67	\$3.87
To be Charged against the By-Product Plant per cord of wood:		
Cost of plant estimated at \$1,170 for each cord per day—		
Labor	\$0.80	
Steam and power	0.35	
Superintendence, supplies and taxes	0.20	
Repairs at 10 per cent of cost of plant	0.33	
Depreciation at 10 per cent of cost of plant	0.33	2.01
Balance in favor of By-Product Plant per cord of wood		\$1.86

are therefore much lower than in a wood distillation plant. The chief difficulty remaining in the commercial development of the process is that of developing proper mechanical devices for opening and closing the retorts and for pushing the contents. Since a plant must be composed of large numbers of small units one man must be able to operate a machine handling a number of retorts simultaneously.

The estimated cost of operation and the returns from a by-product plant of this type are tabulated in Table III. The methyl alcohol and acetone figures are taken from the analytical data as 100 per cent strength and in the absence of actual data on refining losses, 5 per cent loss has been assumed and a further allowance made by not giving to the acetone a higher price than the methyl alcohol. The prices used in the table are those prevailing before the war. The carbon remaining after leaching the black ash is assumed merely to serve as fuel for the plant, though it has been shown to be saleable as a paint pigment and has interested the manufacturers of black gunpowder. No value at all has been assigned to the gases, or the tar which would serve as fuel if it could not be more advantageously utilized. The estimated saving of 5 per cent of the total soda ash in circulation is believed to be conservative, as is also the saving of labor, fuel, repairs, and depreciation on the present type of rotary kiln plant for calcining the black liquor.

Summary

It has been shown both by laboratory tests and by larger mill tests that the concentrated black liquors from the soda pulp process may be subjected to destructive distillation so as to yield 6.9 gal. of alcohol and acetone per cord of wood placed in the digester. The yield from a soft wood such as bass is as good as that from a hard wood such as beech. The only variation from the present process consists in replacing the rotary calciners by retorts in which the liquor is distilled at a temperature of about 600 deg. Fahr. If a 40 deg. Baume liquor is used the distillate contains about 4.4 per cent by volume of alcohol and acetone, no acid, and about 11.2 per cent by volume of tar which contains nearly 50 per cent of phenols. The black ash leaches readily to a clear liquid and the recovered carbon is sufficient to provide the necessary fuel for the whole by-product plant. The by-product plant will effect an additional economy by pre-

venting the present loss of soda which is carried as dust up the stack from the rotary calciners. The net saving by the introduction of a by-product plant is estimated, as shown in Table III, to be \$1.86 per cord of wood cooked in the digester.

University of Michigan.

Current News and Notes

Second Annual Convention of Technical Association of Pulp and Paper Industry.—The second annual convention of the Technical Association of the Pulp and Paper Industry was held at the Waldorf-Astoria, New York, Feb. 6, 7 and 8, 1917, in conjunction with the general convention of the American Paper and Pulp Association. Tuesday, Feb. 6, was given over to executive committee meetings. On Wednesday morning a general session was held, and on Wednesday afternoon a session for the presentation of papers was held. A paper presented at this session by Profs. Alfred H. White and John D. Rue of the University of Michigan on methyl alcohol from spent liquors will be found printed in full elsewhere in this issue. On Thursday morning another session was held for the presentation of papers. The attendance was very good, and a lively interest was shown in all the subjects discussed.

National Lime Manufacturers Meet in New York.—The National Lime Manufacturers' Association held its fifteenth annual meeting at the Hotel Astor, New York, on Feb. 6 and 7. The president of the association, Mr. Wm. E. Carson, presided at the meetings. An interesting series of papers were read, taking up such subjects as revision of standard specifications for hydrated lime, discussion of barrels and packages, welfare work, trade acceptances, use of pulverized coal in lime kilns, group insurance, calcining of lime, continuous hydration and other subjects. G. F. Loughlin of the Geological Survey, author of the annual report on lime, gave an interesting talk on the work of the Survey in obtaining statistics. He said he was working up statistics on magnesium lime and dolomite, in view of their being the future raw materials for our magnesium industry. The members had a rare treat on Wednesday morning when Robt. Lee Montague of Montague, Va. ("42 miles from any railroad"), related a series of anecdotes of Virginia life. He is a natural talker, and his stories from life were rich in humor, and kept the audience in a continual uproar. On Wednesday morning a silver loving cup was presented to Lawrence Hitchcock for his work in establishing and successfully conducting the hydrated lime bureau.

French National Laboratory of Physics and Mechanics.—The Academie des Sciences, according to *Genie Civil*, has resolved to establish a National Physical and Mechanical Laboratory, for the purpose of scientific research directed toward industrial uses. The laboratory will be controlled by a council, of which half the members will be nominated by the Academy, one-fourth by the State Department, and the remainder by the chief industrial associations. The executive control will be in the hands of a small technical committee. Existing laboratories engaged on similar work will be affiliated to the National Laboratory, and will work in close relationship with the latter. Substantial funds will have to be provided for the working expenses of the laboratory, and for the assistance of the affiliated institutions.

Dyestuffs Appropriation.—The Senate has passed the Agricultural bill, which contains a provision for the appropriation of \$49,400 for research in dyestuffs. The money will be used by the Bureau of Chemistry.

Air Drying

By Carl Hering

In some industrial processes the moisture in the air is objectionable, either because the water is an undesirable foreign material, or because it interferes with the use of the air for drying operations; its variability is another objection, as also its tendency to promote bacteriological growth; extreme desiccation acts as a food preservative. In the operation of drying objects in the air, the time required increases rapidly as the air is more nearly saturated, and the objects to be dried are, of course, never any drier than the air which was last in contact with them and which is, therefore, approaching its saturation point on account of the added moisture from the objects. Moreover, the evaporation of the moisture in the objects produces a lowering of the temperature, and this in turn lowers the drying power of the air because the lower the temperature of air carrying a definite amount of moisture, the more nearly is it saturated. Replacing the air rapidly or heating it, are the usual methods for diminishing these objections, but in some cases, as for instance, in the drying of grain, foodstuffs, photographic films, etc., the high temperature and the dust carried by moving air are both objectionable, and on warm, humid days in summer it is sometimes physically impossible to dry such objects properly.

In blast furnaces the water carried by the air robs the furnace of a certain amount of heat, as it must be heated to those high temperatures and is no doubt dissociated also. On a humid summer day, for instance, the amount of water entering a modern blast furnace with the air is about 4 to 5 gallons per minute, which is about equal to what will run out of a large house spigot. It is, however, not quite as bad as though such a formidable stream of water were forced as water into the furnace, as is sometimes alleged, because in the form of vapor in the air the water already contains its latent heat of vaporization, and therefore does not rob the furnace of that formidable amount of energy. In blast furnaces one of the chief objections to the moisture is its variability, making it difficult, if at all possible, to get uniformity of the iron produced.

In the fires of steam boilers this moisture robs the fire of the heat which this water vapor carries off as a dead gas into the chimney. Those who claim that by being dissociated into oxygen and hydrogen at those high temperatures, it adds valuable combustible materials, seem to forget that it first had to rob the fire of exactly as much energy for its decomposition as these two gases give up on uniting again, as they seem to appear in the chimney as steam.

Damp air being very bad for consumptives and as it encourages bacterial propagation in general, it might sometimes be desirable to dry the air in rooms for sanitary purposes.

There are, therefore, cases in which it is of great importance to desiccate the air to a greater or less extent, and many others in which it would be desirable if the cost is not prohibitive. It is, therefore, often a question of the calculation of the cost, and as this cost increases with the degree of extraction of the water, it is also a matter of calculation to find how far it pays to go in the degree of drying.

A number of methods are available. Heating the air reduces its degree or percentage of saturation, and it, therefore, takes up more water with greater facility; and if heated under constant pressure, as for instance, under atmospheric pressure, it reduces the amount of water per cubic foot of the air because the air has expanded; but it does not diminish in the least the

amount of water in a given quantity of air, both measured in pounds, and is therefore, not a process of drying the air.

Reducing the pressure by creating a partial vacuum, increases the drying capacity of the air because the water in the objects then tends to vaporize more readily. The low pressure air itself is really wetter then, in that it contains more water per cubic foot or per pound; hence this is only a process of drying objects, but not of drying the air itself. The water may be said to be sucked out of the objects.

Compressing the air deposits some of the vapor in the form of water and is therefore a true partial desiccation. Such compression, however, also heats the air which itself tends to lower the degree of saturation, and the latent heat of the water which has been condensed, must also appear somewhere as sensible heat. If cooled while compressed in order to get out more of its water, the air will be still colder when expanded again, and this increases its degree of saturation until reheated. Moreover, at the low temperatures produced by expansion there is great danger of ice forming in the valves, which clogs them. This process, therefore, involves complications besides the transferences of heat and the use of relatively large moving machinery; its application is, therefore, limited.

Liquefying the air and then evaporating it again dries it absolutely, as the moisture (besides the oxides of carbon) is all frozen in the process and can be filtered out as a solid. It is one of the few methods for producing absolute dryness, but is expensive, though by using a suitable heat regenerator this cost ought to be very greatly reduced and perhaps it might then be commercial; absolute dryness, however, is seldom required.

Concentrated sulphuric acid, solid chloride of lime, and other moisture absorbing materials, are simple and effective ways of very slowly drying a small amount of confined air, and are much used on a small scale, to which, however, the cost limits them. They are said to absorb even extremely small quantities of moisture and may, therefore, be classed among the absolute methods.

Centrifuging the air at very high speeds ought to concentrate the moisture in one part, and perhaps to oversaturation, thereby rendering the other part drier; but the expense would probably be prohibitive.

But of all the methods of drying, the one based on cooling is the most practical one when dry air is required on a relatively large scale. When the temperature of air containing moisture is reduced to below the so-called dew point (the temperature at which that amount of moisture saturates it) the excess of moisture above saturation at that lower temperature, is condensed as water or ice and may, therefore, readily be separated. At that lower temperature it is then saturated, which means that it will hold or take up no more water, but if heated again to its original temperature after the excess of water has been separated from it, the air will be drier to the extent of the amount of water or ice which has thus been condensed from it; and the lower this temporary temperature was, the greater will have been the extraction, though not in proportion. While this is only a partial desiccation, unless carried to an extreme like in liquid air, yet with modern ammonia ice machines it is theoretically possible to so reduce it that when heated again to normal temperatures, the humidity will be only 2 to 4 per cent, which might well be termed "bone-dry air" and which probably never exists naturally.

As stated above, the applicability of this method generally depends on the cost, and this cost varies with the degree of extraction; hence a predetermination of this cost becomes important. Except in the simplest

cases the calculations are quite involved when all the factors are taken into consideration, and when precision is desired; they should, therefore, not be attempted by those who do not understand them. But roughly approximate calculations are easily made with the aid of conveniently arranged tables.

The principles involved in this process, on which the calculations are based, are as follows: Atmospheric air always contains some water, though it is rarely saturated. The amount of water, termed the humidity, is usually stated in per cent, which is 100 times the ratio of the actual amount to the amount it would contain at that same temperature if saturated; it is measured with the wet and dry bulb thermometers, the readings of which are interpreted by means of tables, as is well known. Care must be taken with the measurements made with the wet bulb, as the rate of fanning or "ventilating" has an important effect if insufficient.

To dry this air it must be cooled first down to the so-called dew point, that is, the temperature at which the water which it contains saturates it. In this first stage of the process the moist warm air follows the laws of gases, and the energy required to be extracted is determined from the specific heat of air and that of the constant amount of moisture contained.

If then cooled below this saturation temperature it begins to deposit its water, and from there on down the air is always saturated at the respective temperatures, hence it no longer follows the laws of gases, but those of saturated vapors. During this stage the energy to be extracted consists of three parts, the two parts necessary to cool the air and the water in it, and the third, the latent heat of as much of the water as has been condensed. If this temperature is below freezing there must be added a fourth part, the latent heat of the amount of ice formed.

Of these parts by far the two largest ones are those for the cooling of air and for the condensation, and of these the former is generally larger than the latter. The freezing energy is relatively much smaller and that to cool the moisture is a small amount, only a few per cent.

After the extraction the air with whatever moisture it still contained at saturation at the lowest temperature must then be reheated which requires a formidable amount of heat. This might be taken from the atmosphere through thin walled metallic ducts and air circulating devices; though the calories then cost nothing, it may be cheaper to heat it more quickly with a heater.

When this dry warm air is then used merely as combustion air in furnaces, the above are all the chief factors entering into the calculations. The duty imposed on the refrigeration machine then is to carry off those calories which must be extracted and which might be termed negative calories, while the duty on the heater is to provide the reheating of the dry air.

But when the dry air is used for drying wet objects, like photographic films or grain, there is an additional and sometimes quite important factor. The vaporization of the water in the objects consumes latent heat. If the drying is done in closed chambers, as it naturally would be, this latent heat will be extracted chiefly from the air and the objects, and will, therefore, cool both. This in turn reduces the drying power of the air and, therefore, the speed of drying. It would also be conceivable that the cold produced by this latent heat energy might freeze the objects; at a uniform temperature of 32° F. the evaporation of each pound of water would freeze another pound. Hence, in such cases the dry air must either be first heated to such a temperature that it will supply this latent heat without cooling itself too much, and this might involve heating it to

a rather high temperature, or if the objects would be injured by this temperature, the air must be heated during the drying operation, or the drying be slow enough to give time to absorb heat from the surroundings.

The cost of this process of drying the air being generally the criterion to decide whether and to what degree it may be practicable to use it, and as this cost may be prohibitive, thermal economies in the process may become quite important, particularly in saving the duty of the refrigerating machine, negative calories, at least at cold temperatures, being far more costly than positive ones in a heater. An accumulation of economies in different parts of the process may together amount to an important saving. An analysis of the most perfect conditions may, therefore, be useful as a guide.

The formidable amount of energy, generally more than half of the total, which must be extracted from the air itself, aside from the water, is, of course, the same in amount as that necessary to reheat it again afterwards, differing only in its sign. It is, therefore, theoretically recoverable by means of a regenerator. If the original warm, moist air be made to pass in one direction through channels with thin metallic walls, and the cold dry air be made to pass in the opposite direction on the other side of those metallic walls, this energy will be exchanged through the thin walls, whereby the ice machine is relieved of that much of its duty, which may amount to about a half; as the moist air then arrives at the refrigerator at a cold temperature, the ice machine would have to supply only the difference; the reheating of the dry air is then also largely saved, as it would come out at nearly the temperature of the incoming air.

Moreover under suitable circumstances much of the water, probably about half or over, would then come out in this regenerator as water, thereby considerably reducing the amount of ice formed and saving its latent heat. As the object is to separate the water from the air, it is taxing the refrigerator unnecessarily to further cool this water after the separation has been effected, and as this usually begins well above the freezing point, some further energy could be saved by having it run off as soon as formed, that is, at the temperature of formation. This would take place in such a regenerator when appropriately constructed.

The cold dried air from the refrigerator cannot, however, take up any more heat in this regenerator than will heat it to the temperature of the incoming air, while the warm moist air could convey to it not only its own heat, but also all the latent heat of the water which is condensed in the regenerator. Hence, additional economy could be obtained, if desired, by cooling the air somewhat more while passing through the regenerator by means of the partially spent cooling liquid or gases coming from the refrigerator. This would take out more of the moisture as water, instead of as ice, and the colder calories of an ice machine cost more than the less cold ones.

In an ammonia ice machine very low temperatures necessarily exist, and as the air will be drier the colder it has been, it would be desirable to make use of these very low temperatures or at least to approach them. This becomes practicable when such a regenerator is used, as the ice machine can then absorb nearly all its calories at quite low temperatures. Makers of ice machines say that -15° F. (-26° C.) can be obtained in regular operation. Cooled to this temperature and then heated again to 70° the air will have a humidity of only 2.95 per cent, hence is extremely dry air. Liquid ammonia boils at -28.6° F. (-3.7° C.), hence as -15°

leaves a margin of 13.6° F., still drier air might be obtained, though the difficulties and the thermal losses increase as the temperature is lower.

Makers say that the efficiency of an ammonia ice machine is reduced 25 per cent by using brine as the conveyor of the cold. Using the ammonia directly would, therefore, increase the capacity of an ice machine 33 per cent and by using refrigerating coils made without joints, by autogenous welding, the danger of leakage in the refrigerating chamber is avoided, and this would make the direct use of the ammonia practicable. It has the objection that steam cannot then be passed through the coils to melt off the ice, as that would contaminate the ammonia with water. But these coils when loaded with ice could for a short time or alternately be used as the ammonia condensers, thereby melting the ice, and at the same time making good use of the negative calories in it.

A common way of producing moderately dry air is to spray it with very cold water. The advantage of this method is its simplicity, the disadvantages are the large quantities of water required to be cooled and forced through the spray nozzles, and that the air is not very dry, though uniformly so. The theoretical maximum dryness would then be 2.11 grains of water per cubic foot or about 0.3 lbs. per 1000 cubic feet at 32° F., and when this is then heated to say 70° F., the air would have a humidity of 24.5 per cent, containing about 0.28 lbs. per 1000 cubic feet, which is not very low, though probably low enough for some purposes.

But these figures represent theoretical perfection and it would require an infinite amount of cooling water. This cooling water must absorb considerable energy in reducing the temperature of the air and in condensing the water, and this energy will, of course, heat this water; moreover the coldest temperature of the air will be that of the cooling water when it is warmest, as it will be the temperature of the water last in contact with the air, that is after it has absorbed this energy. Water, as such, cannot be cooled lower than 32° F., and to cool the air down to say 38° F., would allow only 6° rise, hence enough cold water at 32° would have to be used that it will absorb all this energy and not rise more than 6° F.; the amount will be roughly inversely proportional to this rise. When thus cooled to 38° F. and then heated to 70°, the humidity of the air will be 31.1 per cent, containing about 0.355 lbs. per 1000 cubic feet, which is about 78 per cent of the perfect extraction referred to above.

Assuming the original moist air to be at 70° F., and to have a humidity of about 75 per cent, therefore containing about 0.855 pounds of water per 1000 cubic feet, which is not unusual on a moist day in summer, the cooling water would have to take up a little over 1000 B T U per 1000 cubic feet of air. And as the water is allowed to be heated only 6° F., this means 167 lbs. or about 20 gallons of cooling water per 1000 cubic feet of air for perfect operation. For a blast furnace requiring 45,000 cubic feet per minute it would, therefore, take 900 gallons of cold spray water per minute. The amount of water extracted would be 0.50 lb. per 1000 cubic feet, which is 58.5 per cent, or only a little over half, of what was in it, leaving 41.5 per cent of the water still in the air.

Some improvement in this method may be obtained by passing the air through successive sprays so that it might finally reach more nearly the lowest temperature, 32° F. And the spent spray water of the coldest spray may be used over again for the next warmer one, and so on. A lower temperature than 32° and still have unfrozen spraying water, can be obtained in this method by using a brine for the spray water; the extracted

water will then necessarily gradually dilute the brine which must, therefore, be concentrated again, as by boiling. Using the same water over again also means that it must be filtered, as it contains all the dirt of the air and this might otherwise clog the small spray nozzles. Whether such economies are worth their expense is a matter of computation.

An important advantage of this spraying method is that the air and the cooling water are brought into direct and intimate contact with each other, hence the transference of heat is rapid, and ought to be very nearly perfect. It is for this reason sometimes called the direct method. Whether this advantage is too dearly bought is a matter of computation, and depends also on the particular conditions of the case.

A simple and convenient method of carrying out this cooling process on a small scale is by forcing the warm moist air through cracked ice. If carried out to the extent that the air leaves at 32° F., it will then contain a trifle more than 0.3 pounds of water per 1000 cubic feet, and when then heated again to 70° F., it will have a humidity of 24.5 per cent and contain about 0.28 lbs. per 1000 cubic feet. All the water then leaves at 32° F. and assuming the ice to be no lower than 32°, the extracted heat will all be the latent heat of the ice melted, which is about 144 B T U per pound. Assuming the original air to be 70° F. and to have a humidity of 75 per cent, the cooling will, under perfect conditions, require the extraction of about 1280 B T U, hence the melting of 8.9 pounds of ice, per 1000 cubic feet. Some further economy in this method can be obtained, if desired, by passing the air first through granular material over which the melted ice and extracted water are made to flow or spraying this water into the air before it reaches the ice. Regeneration of the heat in the air itself will add further to the economy. As no useful effect results until the saturation temperature is reached, the ice is being consumed uneconomically until the temperature reached is low. While it costs less ice the lower the original humidity, it is by no means in the same proportion.

For rough preliminary estimates the accompanying Table I may be of interest. It has been reduced to

Table I—1000 Cubic Feet of Saturated Air.

Tempera- ture F°	Pounds of Water	B.t.u. to Reduce from Given Tem- perature to Water at 32°	B.t.u. Per Pound of Water Extracted	B.t.u. to Reduce from 32° to Given Tem- perature	B.t.u. Per Pound of Water Extracted
100	2.82	3,840	1,520	...	...
90	2.11	2,916	1,610	...	...
80	1.56	2,150	1,710	...	...
70	1.14	1,530	1,830	...	...
60	.821	1,030	1,980	...	...
50	.582	604	2,160	...	...
40	.407	256	2,440	...	...
32	.302	0	0	...	...
30	.276	...	...	29	...
20	.176	...	...	358	2,860
10	.113	...	...	914	3,210
0	.0687	...	...	843	3,620
-10	.0407	...	...	1,060	4,060

1000 cubic feet of saturated air at the given temperatures. The second column gives the contents of water in pounds. The third gives approximately the thermal units required to be extracted in order to reduce the temperature from that given in the first column to 32° F. without freezing any of the water; hence it refers to the best that could be obtained by a single spraying with water at 32°, or with passage through cracked ice. It includes the cooling of the air with its water, and the latent heat of condensation. The figures are only approximate and do not include the smaller factors. The fourth column gives the corresponding rates per pound of water extracted in this way. The fifth

is like the third, except that the cooling begins at 32° and ends at the temperatures given in the first column; it therefore assumes that all the water that condenses at 32° has already been extracted as such; these figures must, therefore, be added to those in column 3 if any freezing is done, and it is here assumed that all the free water at 32° is drained off and is not to be frozen. The sixth column gives the corresponding rates of extraction. The amount of water left in the air can be obtained from the second column and will, therefore, be 0.302 lbs. for all the values in column 4, while for column 6 it will be that given in the second column for the temperature to which the reduction has been carried. As the figures are based on the physical laws and constants the inefficiencies in the process must be allowed for in addition.

If the water is all frozen, which is sometimes done, an additional number of B T U will be required to freeze that which would have run off as such at 32°. These figures assume saturation, hence the B T U required to first reduce the air to saturation must be added. If regeneration is used the B T U in columns 3 to 5 will be considerably reduced; a further reduction in B T U would be obtained by cooling in steps; the figures for the B T U are therefore not the lowest possible.

It will be noticed from column 2 that the amount of water extracted for every 10° drop is far greater at the higher than at the lower temperatures. Also that the cost in B T U for extracting a pound of water increases at the lower temperatures, though perhaps not as greatly as might have been supposed.

For saturated air at 60° F. the B T U to cool the air to 32° are roughly equal to those required to condense the water; above 60° those for the latter form the greater half, while below 60° this is reversed.

Makers of ice machines rate them in tons of ice per 24 hours, which they say means that the machines will do as much cooling as that much ice at 32° F. would do in melting to water at 32°, hence this corresponds to the latent heat of melting ice. The latter is about 144 B T U per pound, hence per ton of 2000 lbs. per 24 hours the rate of cooling produced by an ice machine would be an extraction of 200 B T U per minute; this is based on the use of brine as the conveyor; when the ammonia is used directly the capacity is said to be a third higher. From tests of large ice machines using brine, it would require a little more than one kilowatt to operate an ice machine generating 200 refrigerating B T U per minute.

Philadelphia, Pa.

Magnesite Deposits Being Worked in Washington.—The American Mineral Production Company has begun the production of magnesite and various magnesium salts from large deposits owned by the company in Stevens County, Washington. The deposit lies 5 to 10 miles west of Valley, a small town on the Great Northern, about 50 miles northwest of Spokane. It is exposed in several places to widths of 30 to 600 ft., and is estimated to contain an enormous quantity of magnesite, consisting of a coarse to finely crystalline material of reddish to pinkish color. It is not mixed with as much limestone or dolomite as the Australian magnesite. Analyses across wide areas are as follows:

	Silica		Alumina		Iron Oxide		Magnesia	
No. 1.....	0.80	0.40	2.70	3.30	92.10			
No. 2.....	0.89	none	.58	none	95.00			

A number of chemists and engineers have been working for some time on the property, and it is claimed by the company that it is pure and in larger quantities than the Austrian, which formerly produced 90 per cent of the world's production of this grade of magnesite.

The Effect of Centrifugal Force on Colloidal Solutions*

By Eugene E. Ayres, Jr.

Considerable work has been done on certain centrifugal separations which cannot be accomplished by the highest degree of centrifugal force at present capable of commercial application. Some chemists have expressed surprise that gasoline cannot be separated from kerosene, or that soap cannot be mechanically removed from aqueous solution. Others are inclined to doubt that colloidal gold can be successfully deposited from a clear gold sol.

There is one certain method of eliminating guesswork as to the practicability for a given set of conditions—and that is the experimental method. If a careful trial succeeds or fails, the practicability for that set of conditions is no longer a matter of opinion. But pertinent questions may still be asked. For instance, will the result secured by the test represent the best that any type of centrifugal machine may be expected to secure? Is it possible that a higher degree of force can actually remove anything unaffected by the lower degrees? Is it possible that, although complete separation may have been secured, the components are not separately discharged? Such questions can be correctly answered only by thoroughly understanding the complexity of the task confronting the centrifugal separator.

The Colloid State.—Let us first review briefly a few general aspects of colloid chemistry.

The term *dispersed* has been correctly applied to systems involving every size of particle, from the macroheterogeneous suspension to the true molecular or ionic solution. The term *colloid* in its exact sense designates a state of matter with respect to degree of dispersity within the rather narrow limits defined by sub-micro- and amicro-heterogeneity. The largest colloid particles in this sense are about 0.1 μ in diameter—at the extreme limit of microscopic visibility, and at about the limit of retention by the best clay filters.¹ Particles smaller than 0.1 μ may be seen by use of the ultramicroscope, whose lower limit is about 3 μ . Colloidal phenomena are exhibited by dispersoids whose particles are anywhere from 0.1 μ to 1 μ . Most solutions, or molecular dispersoids, are just beyond this limit, a fair average molecular diameter being about 0.1 μ , although some of the more complex molecules are much larger.²

All these systems are polyphasic, but the disperse phase will confer various sets of properties upon the dispersoid, depending upon the specific surface. Therefore the complex system involving many different degrees of dispersion may be said to have distinct phases corresponding to the three series:

1. Particles larger than 0.1 μ .
2. Particles between 0.1 μ and 1 μ .
3. Molecules.

The second division defines the colloid state in its strictest sense. But many of the phenomena that characterize the true colloid characterize to a greater or less degree the coarser dispersoids, whose particles may be even larger than 5 μ , and can be retained by the ordinary filter paper.³

*A paper read at the Ninth Annual Meeting of the American Institute of Chemical Engineers, New York City, January 12, 1917.

¹The μ , or micron, is 0.0001 cm.

²The μ is 0.001 μ or 0.000001 cm.

³Wo. Ostwald-Fischer, "Handbook of Colloid Chemistry," p. 263.

⁴The diameter of the starch molecule is said to be about 5 μ . Lohry de Bruyn and Wolff, Rec. Trav. Chim. Pays-Bas, 23, 155 (1904).

⁵Ordinary filter paper holds back particles of about 5 μ ; a hardened filter (Schleicher and Schull, No. 602 e. h.), those about 2 μ in diameter. (Wo. Ostwald, l. c.).

Certain classifications of dispersoids have been made without regard to degree of dispersion. It will be unnecessary to discuss these distinctions here except to mention the colloids that tend to form a gel. There are several characteristics of these gel-forming dispersoids, especially affecting centrifugal separation. The particles are usually extremely small—even beyond the limit of the ultramicroscope—and the disperse phase and the dispersion medium are composed of both components.⁵ The solid gel has an enormous viscosity fac-

eighths of the salt from a saturated Glauber's salt solution.

The Problem.—When any dispersoid is subjected to centrifugal force—no matter in what type of apparatus—the separation of any individual particle will depend upon the distance through which it must move in a given time before being considered "separated." There are two types of centrifugal machines. In one case, a container is filled with liquid and rotated. The particle must move until it is held in firm contact with the bottom of the vessel before any separation can be measured. In the other case, the liquid is passed continuously through a rotating cylinder and it is possible to draw the liquid from the point nearest the center of rotation while the machine is still in motion. Separation can therefore be detected when the particle has been moved only a fraction of the distance from the surface to the bottom. Our consideration will be limited to this more convenient type.

It would seem that the whole problem hinges upon the proper calculation of the velocity of a suspended particle acted upon by a force. But what is the force? When we think of velocity, we naturally turn to the law of Stokes.

$$U = \frac{f}{6\pi r\eta},$$

where U is velocity of the particle of radius, r , acted upon by the force f , while the viscosity of the medium is η . The formula is based upon the conception that a small body, acted upon by a constant force, will move through a resisting medium with a constant velocity. The normal acceleration is neutralized by friction. The law was applied first to the fall of raindrops through the air. More recently, a large number of important investigations have been based on Stokes' equation, and its accuracy has been verified for liquid as well as gaseous media, and for colloidal particles as well as raindrops.

J. Perrin¹¹ showed the law to be valid for particles as small as one-tenth of a micron. Einstein,¹² in his work on the coefficient of diffusion, assumed Stokes' law to be correct for molecules larger than one-thousandth of a micron, and his results show his assumption to be correct. On the other hand, M. Pellat,¹³ in his investigation of ionic translation in electrolysis, gives some indication that Stokes' law will require a slight modification when applied to particles as small as the potassium ion. Of course our chief interest is in the relatively large particles to which the law has been found to apply without correction.

We are told, then, that colloids will settle by gravity according to a given formula. Emil Hatschek¹⁴ offers a numerical example in the case of a gold sol, and utilizes the very evidently incorrect result as an interesting clue to certain other factors that make for the stability of colloids.

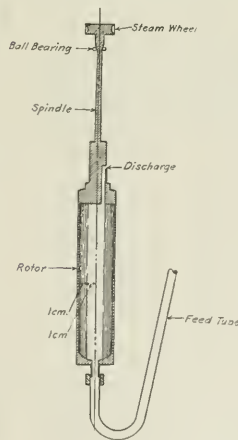


FIG. 1—CONTINUOUS CENTRIFUGE

Temp.	Concentration Agar.	
	Liquid.	Solid.
36°	0.47	.2
5°	0.09	3.0

tor. This would prevent any centrifugal separation even under the most favorable conditions. When the gel is warmed, to liquefy and reduce viscosity, the size of the particle is even further reduced, and the compositions of the two phases tend more nearly to equalize in percentage of components. When this equilibrium is approximately established, the absolute density of the disperse phase is therefore nearly zero.

We shall put aside the gel-forming colloid for the simpler case of the suspensoid whose particles, whether rigid or deformable, have little chemical or solvent affinity for the dispersion medium.

At first glance, it might appear necessary to limit our problem still further. In the case of separation by gravity, the degree of dispersion is likely to change enormously on account of some of the influences commonly known to affect stability. Since time, in the case of centrifugal separation, is a matter of minutes rather than days, we can eliminate these factors.

A Few References.—With reference to the theme of this paper—the study of colloids under the influence of centrifugal force—the first task will be to formulate a mathematical expression of the phenomenon of subsidence. The subject has already been treated in a variety of ways.

The probable influence of gravity on solutions was studied by Gay Lussac. He examined the upper and lower portions of a salt solution in a tube two meters long maintained at a constant temperature for a long time. The results were negative. In 1887, Gouy and de Chaperon, commenting on this work, demonstrated theoretically that the force of gravity was too small. L. Vegard⁶ from thermodynamical considerations, gives an expression for the equilibrium of a solute. H. S. Davis⁷ gives a mathematical analysis of the effect of gravity on a solute, by applying Fourier's law of linear diffusion. His experimental results are also negative.

One of the earliest of the difficult centrifugal separations was made as long ago as 1895 on a mixture of two gases—hydrogen and hydriodic acid.⁸ The gases were whirled for three hours in a machine operated at 2400 r.p.m. with a radius of rotation of 21 centimeters. A 3 per cent difference in concentration was noted.

About twenty years ago, it was observed that subjecting a salt solution to moderate centrifugal force will cause a measurable difference of potential between the center and the periphery. More recently⁹ a centrifuge was successfully employed to obtain a concentration of antitoxic substances in immune sera. Perhaps the most striking work on the centrifugation of solutions was done by Van Calcar and Lobry de Bruyn¹⁰ who were able to crystallize out about three-

⁵Hardy, Proc. Roy. Soc., 1900, 66, 95. Agar gel (2.23 per cent).

⁶Contributions to the Theory of Solutions. (Phil. Mag., Series 6, No. 77, p. 253).

⁷Transactions of the Nova Scotia Inst. of Science. Vol. XII, Part 3, pp. 291-301, 1912.

⁸Bredig, Zeitsch. f. physik. Chem., 17, 459.

⁹R. P. Van Calcar, Voir, Verslagen, March 19, 1904, p. 842.

¹⁰Rec. Trav. Chim. Pays-Bas., Vol. 23, pp. 218-223, 1904.

¹¹"Brownian Movement and Molecular Reality."

¹²Ann. der Physik., 1906, XIX, 289.

¹³Traité d'Electricité, Vol. III, p. 66.

¹⁴"Introduction to the Physics and Chemistry of Colloids," p. 24

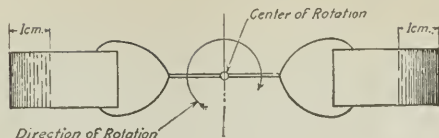


FIG. 2

What are these other factors? It is true that if precautions are taken, as recommended by Perrin, Wo. Ostwald, and others, to avoid small convection currents by observing the rate of fall in a capillary tube, the initial rate of fall will correspond to the equation. But after a time the rate will retard and then cease altogether. In other words, the force of gravitation has been neutralized by other forces acting upward, and the system is at equilibrium.

The Dynamics of Colloids.—Just as Van 't Hoff has been the pioneer in developing the analogy of dilute molecular dispersoids to gases, so M. Jean Perrin has done the first work in extending the kinetic theory to colloidal and even subcolloidal degrees of dispersion. Van 't Hoff had shown that the molecules of a solute in dilute solution play the same part as the molecules of a gas—develop the same kinetic energy, and exert a similar pressure on the walls of a semi-permeable membrane.

The earlier work on the osmotic pressure of colloids indicated a small but invariable value—sometimes so small as to raise a suspicion of experimental error or impure sols, but so invariable as to lead finally to the conclusion that all colloids did exert a definite osmotic pressure. Perrin showed that the osmotic pressure of colloids is due to their own kinetic energy, an energy derived from the molecular energy of the dispersion medium by molecular impacts on the colloidal particle. Kinetic energy implies motion, and colloids are found to possess an irregular, translatory motion known as the Brownian movement, from the name of its discoverer.

Osmotic pressure is thus a property common to all dispersoids whose particles are small enough to show Brownian movement. The largest particles showing this movement are about 10μ in diameter—just about visible to the unassisted eye—but their osmotic pressure is negligibly small. In fact, some particles will settle completely by gravity when less than one micron in diameter.

A second property of some dispersoids is an electric charge. The charge may be either positive or negative, and may be caused either by absorption of electrolytes or by an actual ionization of the particles. Naturally, the presence of equal electric charges of similar sense would seem to lead to an electro-repulsion between particles.

Osmotic pressure can be easily measured in a given case by the usual methods of physical chemistry. The size and sense of the electric charge can be measured by the speed of migration in an electric field.¹⁰ This has been done and the conclusion was drawn that the electro-repulsion cannot be great enough to affect subsidence, although it greatly influences the rate of what is termed "agglomeration crystallization." So there remains only the osmotic pressure.

Instead of measuring this pressure and in some way computing its upward component, it is more convenient to start with the law of distribution derived for colloids by J. Perrin.

The Law of Distribution.—Imagine a liquid containing a number of small particles of uniform size and distributed uniformly throughout the liquid. After the system has been allowed to stand for a time, the particles will have arranged themselves in a definite order. The concentration (number of particles per unit volume) will be greatest at the bottom, and will vary in an exponential manner with the height according to the equation:

$$\log_e \frac{c_0}{c_x} = mgkx,$$

where c_0 is the concentration of particles at the initial level, o , (see Fig. 3), c_x is the concentration at the height x , m is the mass of the particle, g is the acceleration of gravity, k is a constant.

If we put

$$mgk = \alpha,$$

we may write the expression

$$c_x = c_0 e^{-\alpha x},$$

In order to determine the concentration at any point, x , we assume an empirical initial concentration—in

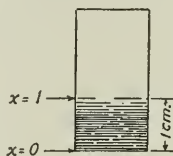


FIG. 3

other words, we take a value, k_1 , to represent the number of particles in a unit volume when the system was uniform.

we can now write

$$k_1 = \int c_x dx = \frac{c_0}{-\alpha} e^{-\alpha} + c'.$$

The depth of liquid is conveniently taken as 1 centimeter. We can therefore integrate between the limits, 1 and 0.

$$k_1 = \int_0^1 c_x dx = \frac{c_0}{-\alpha} [e^{-\alpha} - 1],$$

whence

$$c_0 = k_1 \left(\frac{\alpha}{1 - e^{-\alpha}} \right),$$

and

$$c_x = k_1 \left(\frac{\alpha}{e^{\alpha x} - e^{\alpha(x-1)}} \right).$$

By the substitution of any value of x between 1 and 0 we can find the concentration at x as a function of k_1 and α .

You will remember that

$$\alpha = mgk.$$

k is a constant equal to Avogadro's constant divided by the product of the perfect gas constant and the absolute temperature. Assuming a normal temperature, the constant k is about equal to 3×10^9 , in c.g.s. units. The mass, m , is equal to the volume times the absolute density, d .

$$m = \frac{4}{3}\pi r^2 d;$$

$$\alpha = \frac{4}{3}\pi r^2 d \cdot 980 \cdot 3 \cdot 10^9;$$

$$\alpha = 10^{11} \cdot r^2 d.$$

For particles of different sizes and densities, α can be easily computed and substituted in the formula for concentration, from which the condition at equilibrium

¹⁰The Svedberg. Koll.-Zeitschr., Vol. VI, 238 (1910).

can be shown for any value of α . It is more convenient to express k_i as a weight percentage.

The following tabulation will give a fair idea of the various arrangements with different values of α .

α	c_1	c_2	c_0
1	0.58	1.04	1.60
10	0.001	0.10	10.00
100	10^{-10}	10^{-10}	100.00

In each case, the initial concentration, k_i , was taken as 1 per cent.

Similar values can be easily computed for any other values of α or for smaller or larger values of α , or for other values of k_i .

It is seen that the arrangement at equilibrium is a function of α . But α is the product

$$10^{23}rd$$

so that the radius of the particle that will give a certain α will depend upon the absolute density, d . Thus, when $\alpha = 1$, a particle of low density must have a radius of 10^{-5} centimeter, whereas if the density is high, the radius must be 10^{-6} .

The condition represented by $\alpha = 100$ leaves no room for doubt. Gravity separation will be complete. In such a mathematical application, the liquid can never have a concentration at any point equal to absolute zero, because in such a case the equation for distribution would be indeterminate. But such concentrations as, for instance, 10^{-10} per cent, can be considered as practical zero. The condition represented by $\alpha = 10$, also means a very thorough separation. When $\alpha = 1$, the separation, though not at all complete, is still easily measurable.

It is interesting to note that Zsigmondy found the gravity subsidence of a gold sol to be measurable when the particles were about 75μ in diameter. Such a particle with the high density of gold would make α equal to about 1. Occasionally we come across statements that particles usually will not settle by gravity when as small as 0.1μ . Theoretically the condition of equilibrium shown for $\alpha = 1$ should obtain unless the electromotive forces should bring about agglomeration crystallization. In this case, subsidence will be complete.

We might stop to compute the effect of gravity on the distribution of true solutions where α is very small, but we must go on to apply the formulæ to centrifugal machines.

If it were possible to construct a centrifuge with an infinitely long radius of rotation, we could use precisely the same formulæ for centrifugal separation as for gravity subsidence. But, given a constant r.p.m., the force varies directly with the radius of rotation, and the force is greater at the periphery, 0, than at the surface, 1. In Fig. 4, let the distance from the center of rotation to the periphery be designated by R . The radius of rotation of any point, x , may be expressed by $R - x$. Therefore, we have

$$\begin{aligned} f_o &= \frac{R}{R-x}, \\ f_x &= f_o \frac{R-x}{R}, \end{aligned}$$

where f is the factor multiplying the acceleration of gravity. The centrifugal force, $f_x g$, at any point, x , is equal to a function of x involving the centrifugal force, $f_o g$, at the periphery.

The general expression for distribution in the case of centrifugal force is

$$\log_e \frac{c_o}{c_x} = mf_x g k x,$$

or

$$= m k f_o g x \left(\frac{R-x}{R} \right).$$

$$\text{Let } \beta = m k f_o g,$$

$$\text{and let } k_i = \int c_x dx = c_o \int e^{-\beta x \left(1 - \frac{x}{R}\right)} dx.$$

This function cannot be actually integrated by the ordinary calculus. But approximation by the prismoidal form yields a very nearly accurate result between 0 and 1.

$$k_i = \frac{c_o}{6} \left[1 + 4e^{-\beta \left(1 - \frac{5}{R}\right)} + e^{-\beta \left(1 - \frac{1}{R}\right)} \right].$$

In the special case of the centrifuge represented diagrammatically in Figs. 1 and 4, the value of R is 2, and the depth of liquid is 1 centimeter. The expression therefore becomes

$$k_i = \frac{c_o}{6} [1 + 4e^{-.375\beta} + e^{-.5\beta}];$$

$$c_o = k_i \left[\frac{6}{1 + 4e^{-.375\beta} + e^{-.5\beta}} \right];$$

$$c_x = c_o \left[e^{\beta x \left(\frac{x}{2} - 1 \right)} \right]$$

$$c_x = k_i \left[\frac{6e^{\beta x \left(\frac{x}{2} - 1 \right)}}{1 + 4e^{-.375\beta} + e^{-.5\beta}} \right].$$

This equation is identical in purpose with the simpler form derived for gravity subsidence. k_i represents concentration throughout the liquid before subsidence. It is seen that the factor essentially influencing centrifugal subsidence is

$$\beta = m k f_o g.$$

In the case of the particular centrifuge in mind, f_o is 40,000. Therefore

$$\beta = 4 \times 10^{23} r d.$$

Let us see what happens when we subject a 1 per cent dispersoid to such a force.

β	c_1	c_2	c_0
1	0.80	0.95	1.36
10	0.06	0.08	6.00
100	10^{-10}	10^{-10}	6.00

The results for equilibrium under centrifugal force are seen to be very similar to those for gravity subsidence. Here again we find that separation is good when $\beta = 10$ and practically perfect when $\beta = 100$.

It should be clearly understood that the formulæ given above are expressions of equilibrium. If a dispersoid whose particles are just visible to the ultra-microscope is subjected to a force of 40,000 times gravity, the particles will be thrown down, provided the force is applied for a sufficient time.

Computation of Time.—Many observations in the laboratory under widely varying conditions have led the writer to conclude that precisely the same time is required for each particle of a given dispersoid to move from its position of uniform distribution to the positions of equilibrium. But that this assumption must be correct is evident, not only from observation but from a study of the principles underlying the law of distribution. The particle at $x = 1$ will move with

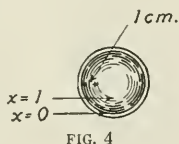


FIG. 4

greater velocity and a longer distance than the particle at $x = 0.5$, but the time will be identical.

The centrifugal force at any point is

$$f_x g = f_0 g \left(1 - \frac{x}{2}\right).$$

The centrifugal force acting upon the particles represented by the concentration, k , can be expressed by

$$f_x g = k f_0 g \left(1 - \frac{x}{2}\right).$$

Earlier in this paper, it was pointed out that the only considerable force opposing gravity is osmotic pressure.

The osmotic pressure of one particle in unit volume, according to the kinetic theory, is equal to the reciprocal of the constant, k , that enters into our functions of x and β . When c_x represents a concentration by weight percentage, the number of particles in unit volume is

$$\frac{c_x}{m},$$

where m is the mass of one particle. The number of particles in the volume $(1-x)$ is

$$\frac{c_x}{m} (1-x).$$

The osmotic pressure, P , at any point, x , is therefore

$$P_x = \frac{c_x}{mk} (1-x).$$

Now

$$c_x = k_i \left[\frac{6e^{\beta x} \left(\frac{x}{2} - 1\right)}{1 + 4e^{-375\beta} + e^{-5\beta}} \right],$$

and if we let

$$\varphi(\beta) = \frac{1 + 4e^{-375\beta} + e^{-5\beta}}{6},$$

we can write

$$P_x = k_i \frac{e^{\beta x} \left(\frac{x}{2} - 1\right)}{mk \varphi(\beta)} (1-x),$$

and since

$$mk = \frac{f_0 g}{\beta},$$

we can write

$$P_x = f_0 g k_i \frac{e^{\beta x} \left(\frac{x}{2} - 1\right)}{\beta \varphi(\beta)} (1-x).$$

The actual force F_x exerted on the particles of a dispersoid can therefore be expressed by

$$F_x = k f_0 g \left[1 - \frac{x}{2} - (1-x) \frac{e^{\beta x} \left(\frac{x}{2} - 1\right)}{\beta \varphi(\beta)} \right].$$

When Stokes' law is applied to particles of given mass acted upon by the acceleration of gravity, it is necessary to put

$$\begin{aligned} f &= mg \\ &= \frac{4}{3} \pi r^3 d g. \end{aligned}$$

Thus, we have

$$U_0 = \frac{2r^2 dg}{9\eta},$$

or for the special case of the centrifuge

$$U_x = \frac{2r^2 dF_x}{9\eta},$$

$$U_x = \theta(\beta) \left[1 - \frac{x}{2} - (1-x) \frac{e^{\beta x} \left(\frac{x}{2} - 1\right)}{\beta \varphi(\beta)} \right],$$

where

$$\theta(\beta) = k f_0 g \frac{2r^2 d}{9\eta} - k f_0 g \frac{\beta}{18k\eta}.$$

Now velocity, by definition, is the distance traversed in unit time. The time required to traverse the distance $(1-x)$, must be equal to

$$\frac{1-x}{U_x}.$$

$$\text{Time } (1-x) = \frac{1-x}{1-x}$$

$$\theta(\beta) \left[1 - \frac{x}{2} - (1-x) \frac{e^{\beta x} \left(\frac{x}{2} - 1\right)}{\beta \varphi(\beta)} \right]$$

But, as we pointed out above, the time is not a function of the distance traversed. It is evident that the distance $(1-x)$ is a function of β , and since the distance to be traversed by any particle depends upon the factor defining the concentration, we may put

$$x = \varphi(\beta) = \frac{1 + 4e^{-375\beta} + e^{-5\beta}}{6}.$$

Substituting in the equation for time, we have

$$\text{Time} = \frac{1 - \varphi(\beta)}{1 - \varphi(\beta)}$$

$$\theta(\beta) \left[1 - \frac{\varphi(\beta)}{2} - (1 - \varphi(\beta)) \frac{e^{\beta \varphi(\beta)} \left(\frac{\varphi(\beta)}{2} - 1\right)}{\beta \varphi(\beta)} \right]$$

This expression gives the time required for particles to traverse from positions of uniform distribution to positions of equilibrium, in a centrifuge whose radius is 2 and whose depth of liquid is 1. The value is the same for particles of given mass and for liquids of the same value of viscosity.

The following tabulation shows the time,* according to this formula, required for separation of dispersoids whose dispersion media is water ($\eta = 0.01$ in c.g.s. units). The density of the particles is taken as 1, and the concentration, k_i , is 1 per cent.

Radius	β	$\theta(\beta)$	Time	
C_m				
10^{-8}	$0.1\mu\mu$	4×10^{-3}	8×10^{-6}	13 days
10^{-7}	$1.0\mu\mu$	4	8×10^{-6}	33 hours
10^{-6}	$10.0\mu\mu$	4×10^3	8×10^{-4}	18 minutes
10^{-5}	0.1μ	4×10^6	8×10^{-3}	11 seconds
10^{-4}	1.0μ	4×10^9	8×10^{-6}	.1 second
10^{-3}	10.0μ	4×10^{12}	8×10^{-1}	.001 second

It will be seen that when β is larger than 100, the time is about equal to $\frac{1}{\theta(\beta)}$ in seconds.

Some objections may be offered to the derivation of our equation for time. Whatever the merits of the case, our equation has two rather unusual characteristics, it is easy to use, and its results, as far as we have observed, will accord with every laboratory measurement.

Practical Considerations.—The great point of superiority of the continuous centrifuge over the non-continuous type is the possibility of handling practical volumes of liquid. When the volume is great, the liquid must pass quickly through the rotor and the time during which the centrifugal force can act on the dispersoid is limited. The time in each case is dependent upon the stationary capacity of the rotor. For instance, if we must pass 10 liters of liquid into a given rotor before the level is high enough to overflow (or discharge), it would seem that the time in minutes during which each unit of liquid remains in the rotor will be equal to the rate of flow in liters per minute divided by 10. As

*It must be remembered that these figures will apply only to the centrifuge exerting a force of 40,000 times gravity and having a radius of 2 centimeters. For any other force or diameter, the proper expressions can be easily derived from the general forms.

a matter of fact, the actual time will be less than this quotient by an interval depending upon the mechanical arrangements of feeding, discharge, etc. Naturally, for any commercial application, a continuous centrifugal will be practical only when it can handle certain required volumes per day. The sizes of particles removed under such restrictions of time will be definitely limited. The capacity of the high speed centrifugal rotor has been limited in practice by strength of materials, but the degree of centrifugal force exerted has not yet reached any such practical limit. It would therefore seem worth while to answer the question: Will any advantage be gained by applying a much greater centrifugal force?

From the tabulation below, it is easy to see a partial answer. These calculations are based on a viscosity of 1. Values of f_0 are taken from 10^2 to 10^7 .

r	10^2	10^3	10^4	4×10^4	10^5	10^6	10^7
100μ	0.5 sec.	5 sec.	50 sec.	12 sec.	5 sec.	50 sec.	5 sec.
10μ	50 sec.	8 min.	12 sec.	8 min.	11 hrs.	8 min.	8 min.
1μ	11 hrs.	11 hrs.	11 hrs.	20 min.	11 hrs.	11 hrs.	11 hrs.
0.1μ	.....	.....	.....	.....	.....	.....	.....
$10\mu\mu$	.....	.....	.....	.....	.....	.....	.....

The values of β for every size of particle with the corresponding centrifugal force shown here are so large that the separation will be complete in every case.

The highest degree of centrifugal force at present commercially applied is 40,000. The lowest practical rate of continuous flow represents in this case a maximum time of about twenty minutes. One per cent suspensions of particles of various densities in liquids of various viscosities can therefore be completely separated by this machine in continuous operation according to the following table:

Size of Particle		Viscosity.
$d = 1.00$	$1.0\mu\mu$	.0001
	$3.0\mu\mu$	.001
	$10.0\mu\mu$	.01
	$30.0\mu\mu$	.10
	0.1μ	1.00
	0.3μ	10.00
$d = 0.01$	$10.0\mu\mu$	.0001
	$30.0\mu\mu$	.001
	0.1μ	.01
	0.3μ	.10
	1.0μ	1.00
	3.0μ	10.00

Any continuous flow machine can be operated with small separate lots of liquid as an ordinary "bottle" centrifugal. In this way it is possible to remove even smaller particles than shown above.

The determining factors are seen to be viscosity and absolute density. The minimum size of particle is affected by both to the same extent, for we see from the approximate equation for time,

$$\text{time} = \frac{9\eta}{f_0 g k_1 2r^2 d'}$$

that

$$\frac{r_1}{r_2} = \frac{d_1}{d_2} = \frac{\eta_1}{\eta_2}$$

In practice, one will rarely meet with a case where the density of the medium and the density of the particle are the same to the second decimal place. When such an equality is approximated, it is well to bear in mind the fact that density increases with degree of dispersity. For instance, the density of a globule of water

$30\mu\mu$ in diameter is 0.5 per cent greater than that of water *en masse*.¹⁷ The density of gold in various forms has been determined¹⁸ as follows:

Molten and compressed.....	19.33
Colloid, ppt. by ferrous sulphate.....	20.71

The question has sometimes been raised as to whether viscosity, the measure of the internal friction of a liquid, can be truly the absolute measure of the resistance to the motion of a particle. One might expect the physical characteristics of the particle to be a potent factor. But it is believed that each colloid particle is enveloped by a permanent film of the dispersion medium, and that whenever the particle is moved, the film will be dragged along.

The accuracy of the figures given for the high power machine has been verified in a number of ways by experimental work. In some cases the value of β has been so small that separation could not be complete and the theoretical concentration of the dispersoid was computed from the equation for c_r . In cases where β was large, and the liquid was drawn off before a state of equilibrium (i.e., complete separation) had been reached, the concentration was computed from the approximate formula for velocity. When β is large the change in concentration is directly proportional to the time, whereas with a small value of β the concentration will vary as an exponential function of the time. In other words, the time required for the particle to move the first millimeter will be very much less than the time required to move the next millimeter.

One interesting fact, which has been confirmed in practice, is that the particles of a polydispersoid (containing particles of several degrees of dispersity) can be separated accurately in fractions by applying various degrees of force.

For instance, a serum containing finely divided fibrin and corpuscular debris of various degrees of dispersity was subjected to a force of about 1700 times gravity. After the force had been applied fifteen minutes, the serum was perfectly transparent to the naked eye. But a fine porcelain filter was immediately clogged, showing that many particles larger than one micron still remained. The liquid was then whirled again with the same force for two hours. No sedimentation could be seen, and the Berkfeld filtration was equally difficult. A portion of the original serum was now passed through the centrifuge, exerting 40,000 times gravity, in which the time of application was five minutes. The resulting liquid contained only a few particles as large as 0.5 micron and 50 liters could be passed through the filter before clogage.

An emulsion of crude oil and water was found by distillation to contain 9 per cent water. When diluted with gasoline and subjected to the force of 1700 times gravity, 0.9 per cent of water was separated in thirty minutes. The percentage recovery was not increased by extending the time to five hours. The same gasoline mixture was passed through the high power centrifugal at a rate that insured less than a minute for separation. The yield of water was 8.8 per cent.

These two examples might be multiplied indefinitely from the writer's experience. They show in a concrete manner that a separation that is impossible to secure by a lower degree of force, even though the time be extended far beyond the limits of practicability, can often be secured in a very short time by a more powerful machine.

The Centrifugal Separation of Solutes.—The experiment of Van Calcar and Lobry de Bruyn, mentioned earlier in this paper, in which three degrees of the salt

¹⁷"Handbook of Colloid Chemistry," Vo. Ostwald-Fischer, p. 12.
¹⁸G. Rose, Poggendorff's Ann., Vol. LXXIII, 1 (1848).

was crystallized out from a saturated Glauber's salt solution by whirling in a centrifuge, is very interesting in view of the theoretics developed above. With the comparatively low force applied, and the extremely small size of the particles, the value of β would be very small (about 10^{-4}). The condition of equilibrium of the molecules would therefore show an increase in concentration at the periphery of a very small fraction of a per cent. But this slight increase means *supersaturation*, and supersaturation has been described by P. P. Von Weimarn as a transition between the true molecular dispersoid and the colloid. The value of β would therefore become correspondingly greater, and toward the end of the period (five hours) the effect of agglomeration crystallization would be quite noticeable. This is, therefore, a somewhat more complex problem than a mere centrifugal separation.

The partial separation of certain gases should, according to our calculations, be within the range of possibility. With 40,000 times gravity, the value of β would be small and separation necessarily incomplete, but the time required to reach this state of equilibrium should be reasonably small on account of the very low viscosity. The continuous separation of gases has not yet been actually tried in practice on account of certain mechanical difficulties of separate discharge, but these difficulties will no doubt be overcome. Complete separations of gases cannot be accomplished by any force less than about one hundred million times gravity.

If a mixture of gasoline and kerosene is passed through the rotor exerting 40,000 times gravity, at the slowest practical rate the difference in concentration between the layers at the surface and at the periphery would be much too small for any analytical detection. If the mixture were held in the rotor for three weeks, an equilibrium would be established, but even then the difference in concentration would be in the fourth decimal place. A force of one million times gravity applied for several days should give a quite appreciable subsidence, but a complete separation would require a hundred million times the acceleration of gravity.

Recapitulation.—Particles of uniform size suspended in a liquid medium will settle by gravity when the product of their mass in grams by the constant 3×10^4 is as large as 10. When the product is less than 10, a partial subsidence will occur until an equilibrium is established.

The only considerable force opposing complete subsidence in this case is osmotic pressure. By the use of a law of distribution, which takes into account the opposing forces, it is possible to compute the concentration at any level when the system is at equilibrium.

When the conditions are such that a particle will not settle completely by gravity, it is possible to cause complete subsidence by the application of centrifugal force when the product of the mass in grams, the force in dynes, and the constant 3×10^9 is greater than 10. Here again a partial subsidence with the establishment of an equilibrium will occur when the product is less than 10.

The time required to establish this equilibrium can be computed from a modification of Stokes' law for velocity.

The highest commercial centrifugal force, 40,000 times gravity, can completely remove particles as small as the lower limit of ultra-microscopic observation, but such a separation will require thirty-three hours when the liquid medium is water. For less viscous media the time will be shortened. Smaller particles can never be separated by this force. Particles just too small to be retained by a fine porcelain filter can be removed in a few seconds.

Gases of different densities cannot be completely separated by any force less than about one hundred million times gravity. The same applies to true solutions. But gases should be partially separated by a much lower force within a reasonable time, whereas solutions in liquid media would require several weeks.

Sharples Specialty Co.
West Chester, Pa.

The Carbonization of Kelp for the Recovery of Potash

By J. W. Turrentine

The development of an American supply of potash for domestic industries is still unrealized, despite the fact that American resources in this commodity have been known for several years and numerous attempts on a commercial scale have been made to develop the various sources indicated. Efforts have been made to produce potash from feldspar, alunite, potassic brines and kelp. So far, the proper combination of character and accessibility of raw materials and feasibility of methods of handling has not been found that insures any adequate supply of potash for normal conditions of industry and market.

As the result of the antebellum experiments and the greatly stimulated efforts inaugurated since the beginning of the European war, it may be generalized that the giant kelps of the Pacific Coast still offer the best promise of supplying the proper conditions for the establishment of a domestic potash industry. Thus, they occur in sufficient quantity, they are accessible and the product, under normal conditions, may be delivered at the market—the Atlantic seaboard—at a charge for freight that is not prohibitive.

Notwithstanding the numerous experiments made at various times and along various lines looking to the establishment of proper methods for treating kelp, it yet remains to be shown what the costs will be for harvesting the material and ridding it of its high water content. The devices so far designed show great promise of the ultimate solution of the problem of cheap harvesting. This is a mechanical problem which safely may be trusted to American ingenuity.

The leaching of kelp in fresh water for the extraction of the potash salts on the laboratory scale has failed to produce promising results. The destruction or the alteration of the organic constituents of a mash of macerated kelp by fermentation, followed by coagulation of the jelly and filtration, has received some attention and may be susceptible of favorable development. The removal of water from the kelp by pressure methods shows less promise because of the gelatinous condition of kelp and the fact of the potash salts being held in solution in the plant jelly. The rotary kiln, found so adaptable and economical in other industries, has been applied with considerable, though not with unqualified, success, to the drying of kelp. Better results seem promised when the kiln is operated counter-currentwise and the drying is effected in stages. The solution of these problems is of prime importance, since any kelp industry must be based on harvesting, and until that operation is solved no industry can be developed; where ten to six units of the raw material to one of the dry is to be handled as in harvesting, the cost per unit quantity must be maintained at a minimum if that of the dry material is not to be prohibitively large.

With the aid of a climate such as that of southern California, of low rain-fall and that restricted to a few winter months, it should be possible to effect drying economically in the open air, if it were not for the me-

TABLE I—WEIGHT OF WATER EVAPORATED FROM A TON OF PEAT AS ITS WATER CONTENT IS LOWERED, BY 10 PER CENT STAGES, FROM 90 PER CENT TO 10 PER CENT

Percentage of Water in Peat	Total Dry-Peat Content, Pounds	Water Content, Pounds	Water Evaporated for Each 10 per Cent Reduction, Pounds	Residue Left for Each 10 per Cent Reduction, Pounds	Total Amount of Water Evaporated, Pounds
90	200	1,800.0		2,000.0	
80	200	800.0	1,000.0	1,000.0	1,000.0
70	200	466.7	333.3	666.7	1,333.3
60	200	300.0	166.7	500.0	1,500.0
50	200	200.0	100.0	400.0	1,600.0
40	200	133.3	66.7	333.3	1,666.7
30	200	85.7	47.6	285.7	1,714.3
20	200	50.0	35.7	230.0	1,750.0
10	200	22.2	27.8	222.2	1,777.8

TABLE II—SUMMARY OF OBSERVATIONS ON DESTRUCTIVE DISTILLATION OF KELP

Item	Percentage	Weight, Grams
Kelp put in retort	100%	3000.
Weight of distillate	19.90	597.
Weight from Scrubber No. 1—wash water and distillate less wash water used		
Weight from Scrubber No. 2	1.74	52.20
Gas	8.40	252.00
Weight of charcoal	16.15	484.50
Moisture	50.10	1503.00
Loss	2.895	86.85
	.815	24.45
Total	100.00	3000.00

TABLE III—DETAILED OBSERVATIONS MADE OF DISTILLATION OF KELP

Hour	Retort Temp. F.	Meter Temp.	Meter	Cu. Ft. per Hour	Cu. Ft.	Remarks
10:20 A.M.	.....	.....	80.873	.....	.....	Started.
30 A.M.	.....	.....	80.878	.....	.005	Bubbles.
11:50 A.M.	.....	.....	81.145	.....	.275	Bubbles, mist.
3:03 A.M.	.....	.....	81.250	2.100	2.377	Pyrom. moved.
0:06 A.M.	.....	.....	81.900	3.000	1.027	Distillate.
16 A.M.	.....	.....	82.750	3.864	1.877	Wash water turning green.
24 P.M.	300	80.5	82.750	3.864	1.877	Tested gas: CO ₂ present.
26 A.M.	.....	.....	83.600	6.075	2.727	Rapid dist.
33 A.M.	320	.....	83.600	6.075	2.727	Samp. 1 not combustible at burners.
29 A.M.	.....	.....	84.175	5.700	3.303	Dist. water in scrub. opaque.
45 A.M.	340	.....	84.800	6.240	3.927	Rapid dist.
47 A.M.	360	.....	85.100	9.000	4.227	Rapid dist.
53 A.M.	370	8.15	.....	.....	.....	Mist yellow.
58 P.M.	380	.....	86.100	6.666	3.527	Dist. brown, gas.
12:00 A.M.	390	82.0	86.450	3.715	5.577	Slightly combust.
0:06 P.M.	410	82	87.173	2.220	.....	Sample 2.
09 P.M.	430	.....	.....	.....	.....	Brown distillate.
12 P.M.	450	.....	88.300	8.100	7.320	Heavy black dist.
25 P.M.	480	83	89.965	9.432	9.092	Samp. 3 lights at burners.
30 P.M.	.....	.....	90.234	.....	9.361	Samp. 4, brown luminous flame.
35 P.M.	570	.....	90.835	4.836	8.836	Sample 5.
37 P.M.	600	.....	91.223	4.320	.....	Shut off burners.
41 P.M.	640	.....	91.223	4.320	.....	Exothermic react.
43 P.M.	670	.....	.....	.....	.....	Dimin. flow of gas.
46 P.M.	710	.....	91.430	1.870	10.69	Dimin. flow distil.
48 P.M.	725	.....	91.333	1.590	.....	Luminous gas.
49 P.M.	740	84	91.563	.....	.....	Started burn.
51 P.M.	760	.....	91.606	1.260	.....	No more dist.
54 P.M.	780	.....	91.669	.....	.....	Gas mist.
58 P.M.	800	.....	91.669	.....	.....	More gas.
1:05 P.M.	820	.....	91.717	3.18	10.834	Sample 7.
07 P.M.	850	85	91.763	3.580	11.78	Dim. flow gas.
09 P.M.	880	85	92.113	3.000	11.24	.....
15 P.M.	830	.....	91.913	1.400	11.64	.....
19 P.M.	880	85	92.113	3.000	11.24	.....
24 P.M.	880	85	92.433	.....	11.56	.....
30 P.M.	900	85	92.633	3.000	11.78	.....
31 P.M.	920	.....	92.853	3.946	11.66	.....
37 P.M.	950	85.5	93.107	2.436	12.557	.....
45 P.M.	980	.....	93.430	2.418	12.557	.....
50 P.M.	1000	.....	93.430	2.418	12.557	.....
51 P.M.	1000	86	93.607	1.740	12.734	Sample 8.
54 P.M.	1010	.....	93.650	840	12.777	Shut off.
2:05 P.M.	1000	.....	93.717	360	.....	.....
2:13 P.M.	970	.....	93.717	.....	.....	.....
33 P.M.	870	.....	93.717	.....	.....	.....
3:13 P.M.	710	.....	.....	.....	.....	.....

chanical difficulties inevitably to be encountered in handling such large quantities of material as would be necessary in a kelp industry. Kelp, when exposed to circulating air, dries with surprising rapidity. Since the first few percentages of water removed from such material, as illustrated by table I,¹ represents the bulk of the water contained, and since this is removed spon-

TABLE IV—ANALYSIS OF GAS PRODUCED IN DESTRUCTIVE DISTILLATION OF KELP—RESULTS IN PER CENT.

Sample No.	1	3	5	7
CO ₂	80.0	70.0	44.0	20.2
Hydrogen	2.0	4.0	10.0	3.3
O ₂	0.5	1.5	0.8	0.5
CO	10.5	8.5	6.7	4.0
H ₂	.....	10.6	23.5	32.0
Methane	2.88	4.4	7.6	7.6
Nitrogen (by difference)	4.12	0.6	10.6	32.4
Total	100.00	100.00	100.00	100.00
Weight per cu. ft.	0.106040	0.094	0.074150	0.057600
Cal. value	107.45	196.70	352.05	282.54

TABLE V—RESULTS OF THE EXAMINATION OF THE LIQUID PORTION OF THE DISTILLATE OBTAINED IN THE CARBONIZATION OF KELP, AND A COMPARISON OF THIS DISTILLATE WITH THAT OBTAINED FROM DOUGLAS FIR AND OAK UNDER LIKE CONDITIONS

Run No.	Material Used	Quantity Used	Moisture	Total Distillate	Total Distillate Less Moisture	Settled Tar	Charcoal	Gas (By Difference)	Total Time of Distillation	Percentage of Dry Weight of Material
		Kg.	Gm.	Gm.	Gm.	Gm.	Gm.	Gm.	Hrs.	
a3	Macrocyrtis pyrrifera	1	116	290	174	.....	465	245	.....	.....
4	Do.	1	116	265	149	.....	470	265	.....	.....
5	Do.	1	116	250	134	.....	480	270	.....	.....
6b	Do.	1	116	255	139	.....	485	280	.....	.....
7	Do.	1	116	277	161	.....	475	284	.....	.....
8	Do.	1	116	275	159	.....	510	215	.....	.....
e9	Do.	1	116	265	149	.....	500	235	.....	.....
10	Do.	1	116	268	152	.....	480	252	.....	.....
11	Do.	1	116	262	146	.....	485	263	.....	.....
12	Do.	1	116	253	167	41	512	355	33 1/2	5.4
d13	Do.	1	116	277	161	60	472	251	4	28
e14	Do.	1	116	242	126	37	487	271	4	28
f15	Do.	1	116	217	101	30	515	268	8	3.4
23	Do.	1	116	277	161	60	485	268	4	49
d24	Do.	1	116	305	159	55	460	235	8	58
16	Douglas fir (Pseudotsuga taxifolia)	1	190	414	224	60	200	326	3	1.5
17	Do.	1	190	424	234	80	276	300	2 1/2	7
25	Do.	1	190	450	260	100	300	250	4	1.6
A18	Oak (Quercus spp.) sawdust	1	366	550	184	45	200	250	4	2.9
19	Do.	1	313	424	111	60	230	346	3 1/2	2.6
20	Do.	1	313	412	99	37	215	373	4 1/2	2.5

a Retort kept at red heat 1 1/2 hours.

b Rapidly heated to red heat.

c Very slow distillation at low heat, occupying 12 hours.

d Distillation started 1:20 p.m.; 1:45 p.m., pyrometer 120° C.; 2 p.m., 160° C.; 2:30 p.m., 200° C.; 3:10 p.m., 220° C.; 4:05 p.m., 240° C. (gases slightly combustible); 4:30 p.m., 260° C. (gas burns steadily); 4:50 p.m., 420° C.; 5:10 p.m., 360° C. (no more distillate).

e Distillation started 8:30 a.m.; 9:15 a.m., 160° C. (large watery distillate); 9:30 a.m., 200° C.; 10:35 a.m., 220° C.; 11:15 a.m., 280° C. (gases slightly combustible); 11:30 a.m., 310° C. (distillate oily; gas burns); 12:25 p.m., 500° C.

f Distillation started 9 a.m.; 9:30 a.m., 140° C.; 9:50 a.m., 170° C.; 10:45 a.m., 190° C.; 12 m., 200° C.; 2 p.m., 220° C.; 2:45 p.m., 290° C.; 3:20 p.m., 390° C.; 4:30 p.m., 400° C.

g Distillation started 8:35 a.m.; 9:10 a.m., 160° C.; 11 a.m., 230° C.; 12:45 p.m., 250° C.; 1 p.m., 300° C.; 2:45 p.m., 410° C.; 4:45 p.m., 530° C.

h Distillation started 8:55 a.m.; 9:05 a.m., 170° C. (gases burn); 9:15 a.m., 200° C.; 10:05 a.m., 270° C.; 11:50 a.m., 290° C.; 12:30 p.m., 500° C.

i Distillation started 1:05 p.m.; 1:40 p.m.; 190° C.; 2:40 p.m., 200° C.; 3:20 p.m.; 250° C.; 5:25 p.m., 500° C.

taneously in the open air, drying floors with plows for turning the material or elaborate racks with mechanical loading and unloading devices suggest themselves. With these disregarded, no methods of artificial drying seem so full of promise as that by means of the direct-heat rotary kiln.

These are matters familiar to those who have studied the problems connected with the potash-from-kelp industry. They are fundamental. And with their proper solution it seems possible that the kelp industry will be established; for dry kelp is a material which appears entirely adaptable to the potash trade. It is a vegetable powder, of a weight of about 50 lb. per cubic foot, which carries about 15 per cent potash (K₂O), and is comparable to the low-grade salts formerly imported in large quantity.

Since dry ground kelp contains 40 to 70 per cent organic matter, freight charges per unit weight of potash can be greatly reduced by the elimination of the organic matter; that is, by the preparation of high-grade potash salts. If, to accomplish this end, incinera-

¹Davis. "Uses of Peat," Bureau of Mines, Bul. 16, p. 110 (1911)

tion methods are adopted, the incineration must be effected at a temperature which does not induce fusion of the potash salts (750 deg. C.). Burning in the open air does not fulfill this condition. Destructive distillation suggests itself and seems to offer the desired solution. It already has been shown that valuable by-products are recoverable by destructive distillation when the latter is properly conducted.² Thus, from the distillation of 3000 g. kelp in a closed retort, the results summarized in Table II. were obtained.

The details of the experiments and observations are set forth in Table III.

²Turrentine, "A note on the Distillation of Kelp," orig. communication, 8th International Congr. Appl. Chem., 5, 313.

The composition of the gas obtained was shown to be as stated in Table IV.

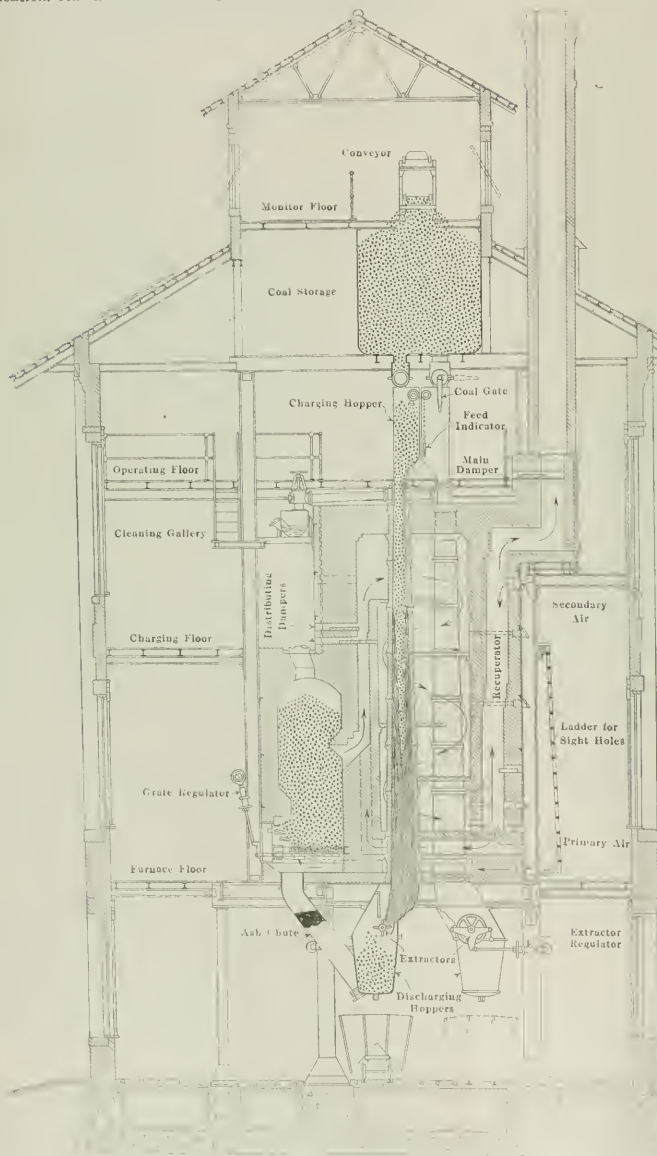
The liquid portion of the distillate obtained when kelp is distilled destructively has been examined by Hoagland.³ His results are summarized in Table V., from which he concludes that "kelp distillates are of no practical importance." The recovery of ammonia from the evolved gases has not been studied.

The distillation of kelp is analogous, and in a sense similar, to that of coal for the production of illuminating gas and coke. As in the latter so in the former a continuous and automatic process, and one in which heat units are faithfully conserved, is desirable. Therefore, in designing an apparatus to accomplish this purpose

the continuous and automatic gas producers now in successful use in the gas and coke industry would be looked to to supply the apparatus of desired characteristics for the distillation of kelp.

There are on the market vertical gas producers which appear to possess features that would make them especially adaptable to the carbonization of kelp. Such a producer would consist essentially of a vertical retort, 25 ft. in height. This may be made in sections to be mounted upon each other and the sections be of such a graduated size that the retort is larger at bottom than at top, thus insuring an unrestricted movement of the charge in its course downward. At top, this may be joined directly with a magazine or charging hopper, from which the charge will pass automatically downward into the retort. Above, the charging hopper should connect through a gas-tight valve with a storage bin for the prepared charge. The latter may be filled by means of a conveyor. At its lower end the retort should be provided with an automatic discharge or extractor, which passes the coke at graded speed into a gas-tight discharging hopper beneath. Gas would pass out at the top of the retort, and be admitted through a tar trap into the main leading to the condenser house.

The retort should be inclosed in an envelope of brick provided with the proper arrangement of heating flues, regenerative devices and baffles. Heat would be generated in the space surrounding the retort. The air supplied for this combustion should be admitted through various passages constructed in the envelope in such a way that the



GAS PRODUCER FOR CARBONIZATION OF KELP

³J. Agri. Research, 4, 40 (1915).
⁴Loc. Cit.

air passing through will be heated in transit. Thus the loss of heat through radiation will be reduced to a small value. Likewise, the primary air, admitted at the bottom of the envelope, should be made to circulate around the bottom of the retort, thus cooling the charcoal contained therein and itself becoming pre-heated. The heat from the waste gases may be recovered by passing them through a tubular boiler situated near the bottom of the stack. Thus the temperature of the gases issuing from the envelope may be reduced to about 300 deg. Fahr.

Such apparatus has been tested for coal and has been found entirely successful with that material. The conditions imposed by the successful distillation of coal, it would appear, are much more severe than those imposed by the distillation of kelp. For the latter, as is evident from Table III, a temperature of 1000° F. is entirely adequate. Probably 750° of temperature would suffice, since considerable heat is evolved by the kelp in undergoing the exothermic reaction, apparently beginning at about 700° F. Coal becomes viscous and swells in coking, while kelp loses volume. Kelp probably would pass readily through a straight retort. It is possible that certain of the distillation products from kelp would condense in the upper portion of the retort, where a low temperature would be maintained, and by admixture with the pulverized kelp interfere with the flow of the charge; in which case the gases could be led out at a hotter part of the retort. In general, it may be said the most serious complications conceivably arising in the carbonization of kelp in the apparatus under discussion appear to be so slight that they readily could be overcome.

The charcoal obtained when kelp is distilled, containing the soluble salts, potassium and sodium chlorides, is porous and easily may be leached. By the application of well-known leaching methods a practically saturated solution of these salts and a charcoal freed therefrom may be obtained. The charcoal could be consumed in an auxiliary gas producer or it might be marketed locally for fuel. The gas evolved from the kelp during distillation, after treatment for the recovery of by-products, would be used for maintaining the temperature around the retort, for which it probably would be more than adequate; and any excess would be applicable to the evaporation of the solution of salts or as an auxiliary fuel in the operation of the kilns. The tar and oils recovered would be useful as fuels if no more profitable application could be found for them.

In short, the system would make possible the complete utilization of any fuels produced and heat units generated. The other by-products obtainable from the distillate could be recovered by methods already well understood, if further experimentation warranted. The large volume of water produced might make the recovery of methyl alcohol and acetic acid impracticable unless they were condensed fractionally. Finally, the crystallization of high-grade salts with the conservation of mother liquors, would make possible the recovery of iodine, for which, after all, there is a certain domestic market.

The cost of such apparatus complete and installed, as constructed for the carbonization of coal, is approximately \$50,000 for a daily capacity of 50 tons coal. This is inclusive of fireproof house. For kelp a cheaper construction would be adequate on account of the greatly reduced temperature maintained and the consequent lack of necessity for the use of high-grade refractory materials. Likewise, on account of the greater ease with which kelp could be carbonized, a greater capacity per retort would be possible with

a consequent reduction in the number of retorts necessary—a value to be determined by experimentation.

The operating expenses would be light. In gas producing plants of large capacity, one man per shift on the operating floor and two, working part time, on the discharging floor, are found to be adequate. The operation of such a plant is almost automatic. Additional expenses would be incurred for the operation of an elevator to deliver the material to be carbonized into the storage bins at the top, and to actuate the discharge rolls at the bottom. Other items to be considered are upkeep and interest on investment.

The principal economy to be expected is the reduction in freight rates, a reduction of from 50 per cent to 75 per cent per unit weight of potash. This item alone would justify the installation. The utilization of the combustible portion of the kelp for the generation of heat to assist in the desiccating operations of the plant would put to use those constituents to which no value would be attached in the market. And finally, other by-products, otherwise lost, would be recoverable if such were found to be justifiable by their value.

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The History and Legal Phases of the Smoke Problem*

By Ligon Johnson

Only the acute phase of the smelter fume problem is new. The problem itself is older than the Christian era.

While both lead and copper were mined and crudely smelted some three thousand years ago it was not until the Roman occupation of the Iberian Peninsula and the British Isles, which occurred but shortly before the beginning of the Christian era, that there was any evidence of smelting operations on a scale sufficiently large to permit of a fume problem.

Around Huelva, Spain, are found more than 30,000,000 of tons of slag from lead smelting conducted there by the Romans. Pliny tells us that more than 20,000 slaves were employed in the Iberian mines. Extensive mining and smelting by the Romans in England and Wales were coincident with the Iberian proceedings.

These metallurgical operations were upon a sufficiently large scale to produce marked results both upon the surrounding country and the smelter workers, but, as these operations were those of a conqueror upon conquered soil, conducted by slaves, imperial Rome failed to recognize that such a thing as a smoke problem did or could arise, and whatever fume question there may have been at that time remained a question only to those who had no chance to answer any phase of it.

The smelting operations of the Romans extended over about 400 years and little is recorded of lead and copper smelting from that time until the sixteenth century. From the revival beginning at this period up to the present century the growth of smelting has been comparatively gradual. In Great Britain smelting was conducted almost wholly in localities where metallurgical operations were of paramount importance, and the communities which grew up in smelter localities were due to and dependent upon the mines and smelters. This fact had much to do with the comparative freedom of British smelting from burdensome fume litigation and legislation. To a lesser degree these conditions applied to the German operations, which, when coupled with the further fact that most

*A paper read at the Joint meeting of the New York sections of the American Institute of Mining Engineers and the American Electrochemical Society on January 26, 1917.

of the early German operations were to a greater or less degree fiscal workings of Prussia, Saxony and Brunswick-Hanover accounts for the early immunity of German smelters. Topographically and with relation to fertile farm lands, the locations of the British smelters were superior to the German, and ultimately a strong legislative barrier was erected around German operations, particularly in the case of new smelters and under new locations of old plants.

Nowadays German smelting is or at least, prior to war conditions, was under supervision of special officials in the nature of mining police and courts. Before construction of a smelter could be begun application for a permit had to be made, and this application accompanied by general data as to location, character, capacity, height of stack, character of ore to be treated and the like. Where a permit was once granted, it was not revocable, but notwithstanding the permit, if damage was done the smelter could be required to change its methods and to install such appliances as would, so far as possible, prevent injury. Where a permit was refused, no smelter could be built. The refusal of a permit by the Bergpolizei or mining police was not final, but an appeal could be had to the Berg Gericht or Mines Court and finally to the Ober Berg Gericht or Mines Court of Appeals, which was the tribunal of last resort. Incidentally, the Bergpolizei had inquisitorial or supervisor powers not only as to damage to vegetation but also as to the safety of the works and the life and health of the employees.

It is supposed by many that the British Alkali Act was aimed at the smelting industry. This is far from correct. The original acts were directed chiefly at the manufacture of soda, acids, and ammonia. In 1861 the House of Lords provided for an inquiry "into the injuries resulting from noxious vapors evolved from certain manufacturing processes, and into the state of the law relating thereto." While the investigation covered smelting as well as the other enterprises, the resulting act (the Alkali Act of 1863) covered only so-called alkali works and provided for the elimination of not less than 95 per cent of the hydrochloric acid produced in alkali processes. By an amendment of 1874 it was enacted that not more than 1/5 of a grain of acid should be contained in each cubic foot of gas escaping from the works.

The original act was made more comprehensive by amendments and revisions of 1874, 1881 and 1892, but outside of operations under the wet copper process and certain zinc processes it was not until 1906 that smelting generally was included, and, even then, no actual regulation was provided as the act so far as smelting was concerned merely declared that the inspectors under the act "may inquire whether in any works in which sulphide ores are calcined or smelted, means can be adopted at a reasonable expense from preventing the discharge from the furnaces or chimneys of such works into the atmosphere of any noxious or offensive gas evolved in such works, or for rendering such gas when discharged harmless or inoffensive."

No limitation was placed on smelting operations beyond inquiring as to the installation of such remedial methods or appliances as might be installed at a reasonable expense. There was no prohibition as to tonnage or fume strength, and the first report of the inspectors touching on smelting was in the forty-fourth annual report of the department for the year 1907, forty-five years after the passage of the original act, and this embodied no smelter regulations.

Fume controversies and the attendant litigation and legislation are of comparatively recent origin in the United States. Probably the first thing in the way of

legislation in this connection was the ordinance of Oakland, Cal., enacted in 1872, prohibiting the erection or maintenance of any smelter within the corporate limits of that city. Subsequent California legislation was enacted by Contra Costa County limiting fume strength and by the State providing for a smelter commission to investigate the effect of fumes liberated in smelter operations. Efforts were also made to prohibit by legislative enactment the elimination of stack gases containing more than two-tenths of 1 per cent sulphurous content. This proposed legislation, however, was defeated. There has been little legislation either by the States or municipalities of the United States.

Not until heap roasting of ores rich in sulphur was practised on an extensive scale was there any litigation of consequence in this country, and to the condition resulting from heap roasting may be charged no small amount of the prejudice by the farmers against smelters and belief by them of the complete destruction of vegetation, animals and soil vitality.

The basis of this prejudice and belief is easily apparent, even to this day, under a visit to Butte, Shasta County, California; Ducktown, Tenn., and other places where heap roasting was extensively practised.

Under heap roasting, strong fumes, in dense volume, were liberated directly on the surface of the earth. These fumes were heavier than air and cold, being practically of atmospheric temperature. They did not float off in the atmosphere but hugged the ground, rolling along in front of the wind in constant volume until absorbed by the soil and vegetation. There was little diffusion and the radius of fume influence gradually widened with the destruction of each successive barrier of vegetation.

The topography of the country surrounding the roast heaps was, almost without exception, sharply declivitous as the roasting operations were conducted in hilly and mountainous regions. The soils of the regions surrounding the smelter sites were coarse and grainy, requiring the binder of the roots of vegetation and humus to hold the soil particles together.

The destruction of plant life adjacent to heap roasting operations resulted not only in the loss of vegetable life above the soil but of the roots below, and, with every rain, the top soil was eroded until considerable areas were not only made wholly barren, but the top soil washed away and only the decomposing rocks and mica were left. In consequence, there was no soil in which vegetation could find a foothold, even when the fumes were no longer present. It was from this erosion that the belief of the killing of the soil first arose.

From what they could already see, the people around the smelters believe the smelter smoke to be the veritable breath of the Upas tree which destroyed all within its reach, and that this deadly agency was daily reaching farther and farther from the smelter and in and upon the homes and farms surrounding the smelter sites. Litigation was then not only threatened, but instituted. First, the farmers sued the Tennessee and Ducktown companies, and upon the failure of these suits the State of Georgia took up the cudgel. The farmers in Shasta County, California, brought suit against the plants at Kennett and Gorum; the Benicia residents and adjacent farmers sued the Selby smelter; the United States, by reason of the ownership of a forest reserve adjoining the Keswick plant, filed its bill against the Mountain Copper Company. Not long after this the Deer Lodge Valley farmers filed their suit against the Washoe Company at Anaconda, and Salt Lake Valley farmers began proceedings against the smelters operating in that valley. The epidemic of smelter litigation was under way.

With these suits developed the early so-called smoke experts. Most of them had been in the heap-roasting communities where the destruction of vegetation and soil erosion had followed the heap roasting. No definite knowledge of fume action was available, and the experts for both plaintiffs and defendants, in the absence of knowledge, began to form pet theories only to be met by pet theories of others directly at variance.

In the good old days of theory an expert could make a casual inspection, or examine a few cross-sections of leaves under a microscope, or make a few comparative tests for the sulphur contents of healthy and unhealthy plants and deliver an epic on what the fumes were or were not doing. The appearance of the country around the old roast heaps and early plants were too big a handicap for the smelters to overcome, and, with the notable exception of the Washoe litigation, in practically every case an injunction followed.

About the time of the institution of those suits the smelters began the abandonment of heap roasting and the development of present-day operations. In this development prior theories expounded by the then experts or testified in the smelter suits had considerable bearing. In one locality everyone was assured that the injury came wholly from the dust particles; in another, from the dust particles as the nucleus for minute drops of acid; in another, from sulphuric acid vapor, which could be seen as a white fume cloud, and practically everything was blamed more than the chief, if not the sole, offender, the SO_2 . In many cases the courts followed these theories in their decrees.

The first development went to long settling flues, smoke houses and dust chambers, cooling and slowing down gases, and taking out so far as possible the solids and vapors. At the Tennessee plants acid making was attempted.

In most of the litigation, under re-adjustment to conform with decrees entered or modifications of these decrees, which modifications as a rule were secured under very substantial cash payments to the farmers, the smelters secured a new lease on life. Several, however, such as the Balakalala plant in California, and the Highland Boy at Salt Lake were completely closed, and passed into history as smelters.

It is interesting to note that not only were the findings of fact in the different cases widely at variance but the conclusions of law in many instances directly in conflict, even in cases in different circuits of the United States courts. For instance, in California and Montana, the United States Court held that the court could consider the balancing of conveniences, that is, that the court, in determining whether or not an injunction would be granted, could weigh the damage which would be done under closing a smelter against the benefits the farmers would receive under an injunction. In the Federal Court in Utah a directly contrary holding was made. In neither law nor facts did the courts coincide.

Some little time was required to make the plant changes to conform with the theories of the experts adopted by the court or the farmers and still further time was required to demonstrate the effectiveness of the changes. Most of the theories failed to pan out and gradually a new crop of complaints and claims that the recent installations did not prevent the damage, began to grow. Some claimants were insistent. Further injunction proceedings were threatened. Plant managers, remembering the results of old litigation, sought to temporize, instead of ascertaining the real facts and meeting them squarely. Some tried to buy peace. Let me say just here that nothing in the Selby report is truer than the statement (page 14) that "the

policy that 'buys off' trouble, as the most expedient commercial method of abating it has been responsible for much of the smelter litigation of this country and the intense ill-feeling that unfortunately exists toward smelters in many smelter communities." It did not take long under this practice for the price of peace to rise to prohibitive figures and a new epidemic of litigation was threatened.

Going back a little beyond this second period of threatened litigation and before the storm clouds of it were yet clearly over the horizon, I think that I may say that the smoke problem was then considered by most plant managers as the least of their troubles. Little or no thought of study was given the question and when it was mentioned it was waved aside. The worst most of them feared was having to judiciously distribute a little peace money.

A number of the smelters, such as the Washoe, Mammoth, Bully Hill, the old Mountain Copper, the proposed Engles smelter and others were either in or adjacent to National Forest Reserves and numerous reports of damage, or threatened damage began to come to the Chief of the Forest Service and Land Office, which reports were in turn referred to the Department of Justice. I was at that time Special Assistant to the Attorney General and these reports were finally referred to me with instructions to prepare and file bills for injunction unless some satisfactory solution could be reached.

While it was probably unknown to the smelters generally at that time, it was never the intention of the Government to close any plant. What it sought was the immediate and serious consideration of the fume problem and active effort to correct harmful conditions where such existed. Only one suit was filed, and that was the suit against the Anaconda plant. In each of the other cases stipulations were entered providing for research work and the installation of the highest types of methods and appliances known to smelting science or else the abatement of the operations producing fumes in harmful quantities until such appliances had been installed and proven elsewhere, upon which they were to be installed at the smelter entering into the stipulation. In the Anaconda case the first scientific commission was agreed upon. We proposed that the smelter operate under the best type of methods and appliances known to science and commercially feasible at the plant and that a commission of John Hays Hammond, Dr. Ricketts and Dr. Holmes, Chief of the Bureau of Mines, be designated as a commission to investigate and prescribe what changes or installations should be made under the agreement.

It was not long after this that the threat of further litigation by the farmers became ominous, and, as I had completed my work with the Department of Justice, so far as smelting matters were concerned, I resigned to become what might be termed smoke or field counsel for the American Smelting & Refining Company.

The first urgent smoke matter in this connection was the Selby litigation, between Benecia residents and the Selby plant, which had been pending a dozen or more years. A flat injunction against the operation of the Selby plant had been granted, which injunction had been fought through the courts and finally approved by the Supreme Court. The case had been through the court of last resort and the injunction was to become effective in a month or six weeks time.

On examining the record I found this suit to be somewhat different from the average smelter suit. Very little claim or injury to vegetation was made. More stress was placed on injury to animals, but the chief ground of complaint was excessive discomfort and al-

leged nausea and illness produced by odors which the witnesses uniformly declared "to smell like rotten eggs" or the sulphur spring of an adjoining county which spring gave off quantities of sulphureted hydrogen.

An examination of the Selby plant disclosed that, regardless of what lead loss there might have been at other times, under changes made or under way no lead loss would occur and therefore no possible source of injury to animals could exist from the plant's operations and that there was no appreciable amount of sulphureted hydrogen given off by or generated in the smelter plant.

In the San Francisco region in the spring and summer months constant trade winds blow and these winds follow a direct line from the Selby smelter to Benicia where most of the complaining witnesses lived. Beyond the Selby plant but also directly in line of the trade winds over the Selby plant was a large oil refinery and asphalt works. The odors complained of by the witnesses all came in the early morning hours, and investigation disclosed that at the times involved in the testimony, the oil and asphalt stills were not capped and were poured at 3 or 4 o'clock in the morning. Here then was a source of odors, which odors traveled on the same winds that carried the Selby smoke. The smelter was guilty of none of the things upon which the injunction was based. Capping the oil and asphalt stills practically disposed of the unpleasant smells.

We notified the county attorney and commissioners of Salano County of these facts and stated that we proposed to decline to observe the injunction prohibiting the operation of the plant. This would mean additional long drawn out and expensive litigation. To obviate such a situation I proposed that the whole matter be referred to a commission of scientists of the highest type, the members to be agreed upon jointly, and the finding to be entered in the Selby case as the finding and decree in that case. Every access to the plant and full-facility for examination was to be given the commission. After many conferences an agreement along these lines was arrived at and the Selby Commission came into being. The members of the Commission were Dr. J. A. Holmes, Director of the Bureau of Mines; Dr. E. C. Franklin, then director of the Chemical Laboratories of the U. S. Public Health Service at Washington, and Ralph A. Gould, a chemical engineer of San Francisco. With the Selby commission came the first scientific research in smelter fumes along the lines of normal field conditions.

The examination of the Selby Commission extended over a period of about a year and a half and in the end clearly demonstrated that the smelter was doing none of the things found against it in the original decree; and the injunction was vacated.

Shortly after the time the Selby Commission began on its work the murmuring of discontented farmers became much louder. Crops had failed in many localities and wherever this crop shortage was in a smelter locality the smelter was blamed. This was particularly true where prior payments had been made to farmers. Peace was quoted at war prices.

As I before stated, this was very shortly after the Selby Commission began its work. Besides the research just beginning under the Selby Commission, there had not been in the United States or elsewhere, any experiments or research work with smelter fumes or SO₂ under natural field conditions. It is true that Haselhoff and Lindau, Von Schroeder and Reuss, E. Schroeter, Wieler and Hartleb, R. Hartig, Wisliucenus, Freitag, Sorauer, Ramaun, Gerlach, Schnitz-Dumont, Sabachnikoff, Haubner and Stockhardt in Europe, and Haywood and Pierce, and to a limited extent, Ebaugh and Talmage in the

United States had carried on some experiments, but in none of these were normal field conditions approximated. Some fumigations were carried on with leaves or twigs or small parts of plants in bell jars. Others were in hermetically sealed cabinets, or "smoke houses" so constructed that only abnormal conditions could result. The plants used were grown in pots or flats and were grown and kept under conditions that were not normal. The fumes introduced were from burning sulphur or sulphur and alcohol or else concentrated SO₂ let in from a tank or gas burette. The concentrations were unknown, absorption was not considered nor were chemical analysis of the air made. Environmental factors of temperature, humidity, light values, barometric pressure and time element of exposure were not considered. The plants used in the experiments were not grown to maturity nor were their food or crop values ascertained. As a matter of fact at the time these experiments were conducted, no quick and accurate method of air determination was even known to the experimenters. Even had these investigations been conducted with normal plants, under natural field conditions, the lack of knowledge or records of actual fume strengths reaching the plants and of the environmental factors involved, would have rendered the experiments practically valueless.

Some investigators of smelter regions placed much reliance on the sulphur content of plants collected in smelter neighborhoods notwithstanding the fact investigations in the Department of Agriculture have shown that the sulphur content of the same plant may vary as much as 3000 per cent at different times during the season and at the same period the content of the same species of plant will vary markedly, particularly under different percentages of soluble sulphur in the soils, which variance frequently occurs at short distances.

In other words, from farmers and experts the smelters were coming in for full blame for all crop failures and the managements actually did not know whether or not they were doing the damage. From my past experience, I knew that there were numerous plant injuries attributed to smelter smoke which even the most competent expert could not differentiate by mere observation or even microscopic study. Numberless diseases and injuries which were not caused by smelter smoke were pointed out as evidence of smoke damage.

No plant manager knew how much, if any of the damages attributed to the smelter was caused by it, and if there was damage, what operation of the smelter or element of waste had produced the damage. And, too, with the payment of damages communities of smoke farmers grew up. Their idea of farming was to let their places grow up in weeds and collect from the smelter the value of the maximum crops ever produced. Many smelters had paid damages for conditions which, it later developed, were not remotely attributable to smelter operations; but the farmers having once been paid insisted on continued payments. The price of peace was rising above the possible profits of smelter operations.

The time for theorizing had passed. It was necessary that the smelter managements know just what damage, if any, was being done, and if there was damage, how it was done and what was necessary to prevent such damage. Under my urgent recommendation, the first research department to ascertain all this was installed and it, in conjunction with the Selby Commission, blazed the way for real smoke engineering.

This research work involved chemistry, plant pathology, plant physiology, entomology, agronomy, dairy husbandry, and veterinary toxicology and meteorology.

You may wonder why all this was necessary just to find out whether or not the smelter was doing any of the things claimed and why one or two experts familiar

with the appearance of vegetation in smelter regions would not have sufficed.

We have to know first what smelter fume or parts of fume would do damage; how the injury could be caused; what conditions were or could be confused with smoke injury and finally, where damage was or could be done, what steps were necessary to obviate it.

This meant first extensive research work under normal field conditions to ascertain the effect of smelter eliminations upon vegetation and animal life. The time at hand is too short to go into a minute description of this research work. It will probably suffice to say that we found that dust and acid vapors were practically negligible quantities in the fume problem so far as vegetation was concerned. Where damage was done, this could be traced almost if not wholly to sulphur dioxide. The average vegetation can stand fifty times the strength of acid vapor that it can resist where the sulphur is administered in the form of SO_2 . In the average smelter fume the acid vapor is but a small fraction of the sulphur content, this latter being chiefly confined to sulphur dioxide.

It then became necessary to ascertain the relative resistance of the various plants to sulphur dioxide and the conditions under which injury occurred when the SO_2 was present in sufficient quantities to do damage.

To develop this fact it became necessary to know exactly how smelter fume acts upon plant life, how it obtains ingress to the plant structures and its effect after its absorption into the plant.

It may not be amiss just here to describe in a few words how this ingress comes about and the results which follow. In the beginning we found that only during the period the plant was in leaf could injury occur. Subjecting a plant to SO_2 or other fume while not in leaf produced no result. In most instances, and practically without exception in alkaline soils, we found that treating the soil in which the plants grew with sulphur or sulphuric acid, that is, dusting or spreading crude sulphur upon the soil or spraying the soil with acid, resulted in increased crop yield. Sulphur administered in this way was a benefit and not an injury. This conclusion was verified by independent experiments conducted at the University of California in Berkeley, at an experiment station in Oregon, and at the experimental farm of the Anaconda Copper Company.

The question then narrowed down to the effect of smelter fume through leaves and on leaf structure and to present this clearly it is necessary to describe the ordinary leaf and its functions.

All leaves under normal field conditions, in climates such as we have to deal with here, have an epidermis covering both the under and upper leaf structure. This epidermis is impervious to moisture and for all practical purposes, except where stomata or breathing pores occur, is also impervious to gases. These breathing pores are so small that considerable magnification under a microscope is necessary to see them at all. The stomatal openings are entirely too small to admit the minutest suspended water globules or particles of mist or vapor. The stomata at the leaf surface, are faced with two guard cells, that are also covered by practically impervious epidermis, which guard cells, under certain leaf functions, open or close the stomatic chamber. With the guard cells closed the leaf under ordinary conditions presents impervious surfaces to the elements. The inner content of the leaf, or the mesophyll, is composed of palisade cells, collecting cells and sponge parenchyma, in which, under this action of light, starch and sugar are formed and plant food manufactured and supplied the plant.

We next found that under conditions of absolute

closure of the stomata, the plant was a number of times more resistant to SO_2 than when the stomata were open. Under usual conditions the stomata forms the point of ingress of gas. It followed, therefore, that where an external condition brought about the closure of the stomata it brought about increased resistance, and we finally worked out four factors in chief in fume injury, where sulphur dioxide is present in strengths sufficient at any time to bleach plant life, these factors being light (the stomata are closed during darkness), humidity, temperature, and constant wind direction. The bearing of the latter comes from the fact that injury except from abnormally strong fumes does not come from mere fume puffs but from steady application of SO_2 for several hours. The other three factors bear upon stomatal opening.

After we had learned the strength of SO_2 necessary to produce markings upon plant life under field conditions, it became necessary to know whether or not SO_2 was present in such quantities in the field. It was also necessary to know accurately the wind constancy and direction, the limits of the smoke stream, temperature, humidity and general weather data. Complete installation of standard weather instruments, under the supervision of the local U. S. inspector, was made; and portable laboratories, that is laboratories set up in small automobiles which could follow the smoke stream as well as make general tests, were secured. This was in addition to the fixed air stations maintained. Under the method of air analysis devised by Mr. J. R. Marston and later refined by Mr. A. E. Wells, chief chemist for the Selby Commission, quick and accurate determinations of air samples were possible, and, more important still, these samples would be taken in a few seconds time and, in this way, the constancy or inconstancy of the SO_2 determined. For the smelter plants we cross-sectioned the several flues at the base of the outlet stacks and the stacks to afford analysis of their contents and installed self-recording thermometers at appropriate points in the flues and stacks for accurate and complete data as to gas temperatures.

With this knowledge the next step was to ascertain with scientific exactness the cause of crop failure or injury where the appearance of external conditions, and often even microscopic cross sections, were seemingly identical with the results of smoke injury, but where our other investigations had developed that smoke injury could not have occurred. There are many diseases, pathological condition and insect injuries, which, both externally and under the microscope, present an appearance practically identical with that of smoke injury. With the completion of this investigation, a survey of the so-called fume zone followed.

It is interesting to note that, in determining the injury of plants by disease, we can establish our diagnosis with scientific exactness not possible in the diagnosis of diseases of human beings or animals. We can establish our diagnosis beyond the possibility of doubt or question. This is done by what is known as the pure culture method. The unhealthy plant is pricked by a needle pointed instrument which in turn is dipped in a special and pure plant jelly and a culture of the disease organism is grown. The disease organism is isolated and reproduced. A healthy plant is then inoculated with this culture and after the disease develops comparison of appearance is made; a second culture is made from the inoculated plant and a second inoculation of a healthy plant follows, and in this way the disease organism is isolated, the disease and appearance reproduced and the diagnosis established beyond a reasonable doubt.

For insect causes, we find and collect the causative insect. As some insect colonies, although numbering

thousands, are so small that the individuals are only observable under very high-powered microscopes, and others work wholly out of sight and beneath the soil, it required a competent entomologist to handle this phase.

It will suffice to say here that we proceeded through the whole list of plant pathology, physiology, entomology, agronomy and dairy husbandry and veterinary toxicology with equal care and certainty. The time is too short to go into detailed explanation of the plan pursued under each.

One other agency in smoke determination has been established with relation to plant life and that is the evidence of so-called guide plants. There are certain plants, such as barley, which are especially susceptible to fume injury and will show bleaching long before the possibility of injury to other plants. Where the guide plants are unmarked, it is self-evident that the trouble with adjoining hardier plants is not smelter smoke.

In the work I have mentioned, we not only secured information valuable to the smelters, but we accomplished actual and beneficial conservation so far as the agricultural resources of the country are concerned.

Scientific farming is not yet widely practiced. Farming methods are often handed down from father to son. Year after year the same crops are planted, often on the same soil. This applies to farming generally and not merely to smelter communities.

In many places not only do the soils become impregnated with disease producing fungus and germs, but the result becomes so wide-spread that no healthy seed can be secured in the community. It often happens that disease conditions may largely be eradicated by proper treatment and planting of the seed and crop cultivation, but these facts as well as that the seed is diseased, are unknown to the farmer.

I recall a case where enormous claims for loss of potato crops were filed against a smelter. Upon investigation we found both the potatoes and the soil of the region highly infected with two of the most disastrous of potato troubles, rhizactonia and fusarium. A subsequent search of the seed stores in the community failed to disclose a single healthy sample of seed. Naturally the potato crops were failures. The sad part of it was that there was no need of this loss. Healthy seed procured elsewhere and planted in soil where potatoes had not been grown for several years, would have given the old time record crops, and proper treatment of the local seed would have produced infinitely larger returns.

Most of the diseases and insect conditions of agricultural communities are largely preventable and for those that are not, steps may be taken to greatly reduce the harmful effect. Much of the troubles can be directly pointed out to the farmer, and the means of eradicating or lessening these troubles can be shown him. This, of course, involves the demonstration that the unhealthy crop conditions are not attributable to the smelter.

The farmer who follows the suggestions for eradicating unhealthy conditions soon finds his crops exceeding those of his neighbors who have failed to observe the same precautions. In this way, gradually it is true, the influences of the smelter's experts is felt, a friendlier feeling is engendered, agricultural conditions are improved and actual conservation accomplished.

This brings us down to one final theory which in some places is still firmly entrenched and threatens possible trouble. I refer to visual clearance and the belief that anything seen coming from the smelter stack should be labeled with a skull and cross bones. Our investigations showed that the visible fume was little to be

feared as an actual instrument of damage to vegetation. Under former operations where a good part of the lead content of the ore was blown up the stack and where heavy arsenic fumes were given off, this metallic loss had some connection with certain animal troubles, but had little effect on vegetation. Where this character of loss was not involved, the visible fume was and is chiefly dangerous from the psychological point of view. By this I mean that most farmers (and many will be honest in their belief) will assert, so long as there are visible stack eliminations, that every crop failure is due to the smelter fumes. Therefore, to meet this, it will be advantageous to obtain the greatest possible clearance up to the point—and I want to stress this especially—where the efforts to secure visual clearance renders the smelter operations more liable to do actual damage. Beyond this point it is better to try to educate the farmer and get rid of the belief. Just because a farmer sees dense volumes of soft coal smoke pouring from the stacks of manufacturing plants, business houses, engines and the like, he feels no uneasiness about his crop. There is little if any more danger to crops in the visible smelter smoke. And, too, even where the belief of damage is deep seated, mere belief can be met by facts, but actual damage cannot be dodged because the smelter management seeks to meet some psychological condition; for mere belief won't last long in the face of actual damage.

Get clearance first for actual recoveries, and loss of toxic solids, and next, so far as possible, to meet any physiological conditions, but do not place visual clearance above the likelihood of actual damage.

Our investigation and the temperature curves we have worked out have shown us that where there is fume injury the answer to the problem is in hot gases, gas dilution, and high stacks. Anything that cools or slows down the gases or results in their liberation at low altitudes invites, to say the least, the probability of actual damage. Promising a community complete visual clearance or encouraging the belief that visual clearance means impossibility of damage is borrowing trouble for the future, for such a clearance, unless I am mistaken, means low gas temperatures.

These smoke problems are bringing to the front a new specialist, the smoke engineer. The far-sighted smelter management, under existing conditions, for all new construction, and even alterations and additions to old plants, will find this new expert a necessity rather than a luxury. The best way to take care of trouble is, not to stop it after it has started, but to prevent its starting. Many of the smelters realize this and those that do, in the matter of fume problem, welcome the coming of the smoke engineer and specialist.

Spring Meeting of American Chemical Society

The condensed general program of the spring meeting of the American Chemical Society, to be held in Kansas City, Mo., April 10-14, is as follows:

Tuesday night, April 10—Council meeting.

Wednesday morning, April 11—Opening session.

Wednesday afternoon, April 11—Opening session, continued, or section meetings.

Wednesday night, April 11—Smoker.

Thursday morning, April 12—Section meetings.

Thursday afternoon, April 12—Section meetings.

Thursday night, April 12—Banquet, or open.

Friday morning, April 13—Section meetings.

Friday afternoon, April 13—Excursions.

Friday night, April 13—Banquet, or open.

Saturday morning, April 14—Excursions.

Potash, as a Byproduct from the Blast Furnace*

By R. J. Wysor

Since the outbreak of the European war, few problems of raw-material supply have commanded more nation-wide attention than potash. It is well known that before the war the domestic production of potash was an insignificant percentage of the imports. The average annual importation of raw potash salts for several years prior to 1914 was slightly over 300,000 net tons, and of other potash manure salts about 700,000 tons. The sudden and almost total cessation of these imports created a unique and stringent situation. Methods of recovering potash from feldspar and other native mineral sources, and reclamation from hitherto waste products, have received a marked impetus. Soaring prices have been a keen incentive to research and industrial development.

Although several brief articles concerning the possibilities of potash recovery have appeared in recent trade journals, it still may be a matter of surprise to the average technical mind that potash might be reclaimed as a profitable byproduct in the manufacture of pig iron. At the present time it may be of special interest to present some data, largely of a technical nature, on this subject.

A fairly thorough search of the literature reveals a number of articles concerning salts of the alkali metals in the blast furnace. Many of them deal with the theoretical rôle of alkali cyanides in the furnace. Several discuss the probable effect of the alkalies on the furnace brickwork. Two or three ambitious patents have been granted for reclaiming potash or other products from blast-furnace gas. However, we have heard nothing further as to the practical application of these patents. Little literature of importance has appeared during the last 10 years concerning alkalies in blast-furnace practice, and I have discovered no record whatsoever as to the actual sale or commercial disposal of flue dust for its potash content until this was inaugurated in our plant at Bethlehem.

About 4 years ago, in the course of investigating blast-furnace stove efficiencies, I analyzed the fine, yellowish fume of which a considerable quantity was removed from the bottom of the stove checkerwork. The sample was found to contain, among other constituents, about 15 per cent water-soluble potash, which was somewhat surprising. This induced an investigation, which showed that considerable quantities of this material, hitherto a waste product, could be recovered from our stoves and gas-fired boiler settings. A search for a market was made without immediately satisfactory results. One fertilizer dealer claimed that the alumina content was too high. Others wished to make practical tests, and we furnished large samples for a full season's demonstration, satisfactory results being reported. But the pre-war-time prices offered hardly seemed to justify the trouble of reclaiming the dust.

With the beginning of the war and the subsequent spectacular rise in the potash market, conditions were changed. Knowing just what dust to recover, reclamation was immediately commenced, a satisfactory contract was negotiated, and this company has been disposing of the dust at a good profit ever since.

OCCURRENCE OF ALKALIES IN RAW MATERIALS

Potash doubtless occurs almost entirely in some form of feldspar or clay in all blast furnace raw materials.

*Abstract of a paper to be presented at the New York meeting, February, 1917, of the American Institute of Mining Engineers. The author is superintendent of blast furnaces at the Bethlehem Steel Company.

At Bethlehem we receive ores from many quarters of the globe, and an attempt was made to discover whether the relative percentages of alkalies in the various ores bear any special relation to the source, mineralogical nature, or to the silica and alumina contents of these ores. No striking relation was discovered, except that the manganese ores, from widely separated sources, were found to contain relatively high percentages of potash as compared to most iron ores. Iron ores of this country, including those of the South, containing upward of 1 per cent potash, or over, seem to be restricted to small areas.

The percentage of potash in different varieties of limestone and dolomite used as flux varies greatly, largely on account of intermixed clay, and may be surprisingly high. Per unit weight, the potash content of our flux charge at Bethlehem is considerably higher than in either the average ore or coke charge.

Few data are available on the alkali content of coke from different localities. Various standard Connells-ville cokes which we have examined have shown a much lower alkali content than our local byproduct coke made from West Virginia coals.

It may be a matter of some surprise to note that, with one exception, the soda contents of all the iron ores, the coke and the flux, subsequently listed, are much higher than the potash contents.

In the course of this investigation, samples of slag and flue dust from all of our Bethlehem furnaces were collected continuously over a period of 4 weeks during June and July, 1916, and analyzed for the alkalies.

The ratio of potash to soda is considerably higher in the coke than in the ore and stone. For each ton of pig iron produced, nearly 60 lb. of the alkali oxides are charged, constituents which certainly are of considerable importance in the working of the furnace, yet of which relatively little cognizance has been taken in the past.

However, due largely to the relatively high percentage of alkalies in our fuel and flux, and on account of the considerable quantity of alkali-bearing flue dust removed, it is my opinion that more potash and soda are charged into our blast furnaces, per unit of iron produced, than in any other large plant in this country.

ACTION OF ALKALIES WITHIN THE FURNACE

It is probable that a considerable part of the potash and soda charged into a blast furnace is evolved from the top by direct volatilization or heat decomposition, though alteration by chemical reaction of the alkaline salts or compounds liberated may occur before they have left the furnace. It is certain that a large part of the alkalies are carried down into the hotter zones of the furnace and are converted into cyanides by reaction with red hot carbon. Some investigators have attributed an appreciable part of their ore reduction to the action of cyanides, inferring that after being oxidized and driven to the cooler upper portion of the furnace they condense and are again carried down into the reducing zone. Whatever the action, it is self-evident that eventually the same amount of alkalies must be carried out of a furnace that is charged, and this takes place through the following avenues of escape:

1. *In Chemical Combination in the Slag.*—The literature is almost barren with reference to the presence of alkalies in blast-furnace slag. On account of the readiness with which the compounds of these metals are sublimed and carried out of the furnace with the gas, it might be inferred that only a negligible proportion would be found in the slag. This is far from the truth. Average samples from each of six furnaces in

operation for two bi-weekly periods were carefully analyzed for potash and soda.

The calculated weight of slag produced during this period was about 0.52 ton per ton of pig iron produced, which would account for a loss of alkalis as follows:

	Pounds	Per Cent of Total Charged
Average potash in slag per ton pig.....	4.5	20
Average soda in slag per ton pig.....	6.3	17

The percentage loss of the two alkalis in the slag is seen to be about the same, being somewhat greater in the case of potash.

2. *As Cyanide or Other Volatile or Inflammable Compound through the Iron and Cinder Notches.*—Part of the fume arising from the molten iron, and especially from the slag running from the furnace, is undoubtedly alkali compounds. I have often noticed a peculiar lavender or violet flame around the iron and cinder notches during casting or flushing, which I believe is due to some alkali salt or salts burning. The fume arising from the iron and cinder runners certainly contains a considerable percentage of alkalis.

3. *By Liquid Evaporation or Decomposition from Gas Around the Tuyères, Coolers, Mantel and Cooling Plates.*—Occasionally while removing a tuyère or cooler, a stream of liquid "cyanide," resembling water, will run out of the furnace, or can be seen exuding from the lining.

When cooling plates above the mantel burn out, due to the failure of the water supply, and a little gassing has commenced, beautiful white and yellow or yellowish-red crystals often build up around the apertures.

Liquid material sometimes also exudes from around the mantel plates and solidifies in heavy columns or stalactitic masses on the shell. This substance, containing some cyanides, is highly deliquescent.

4. *By Combination with the Brickwork or as an Accretion in the Form of Cyanide, Etc., and Removal when the Furnace is Blown Out.*—This is, of course, a relatively small but very interesting part of the alkalis charged during a campaign. Several authors have suggested that destruction of brickwork in certain stacks, particularly in the middle and upper zones, was due to action of alkalis. However, so far as chemical action is concerned, rather more importance has been attributed to reaction between carbon monoxide and iron oxide spots in the brickwork, with subsequent disruption of the brick mass. The destruction of linings is doubtless hastened somewhat in furnaces in which the burdens are relatively rich in alkalis.

The average sample of the hearth brick used in one furnace lining at Bethlehem by careful analysis showed a total alkali content of 1.60 per cent. After blowing out, a sample was secured of a number of these brick near the bottom of the hearth, appreciably discolored when broken, which showed a total alkali content of 3.36 per cent. Higher up in the lining the alkali enrichment is greater. Samples of pure white, mixed cyanides, etc., have been recovered in various plants from protected crevices in the brickwork, around the boshes after furnace campaigns, and a great deal more would be found if the contents of the stack could be removed dry.

The presence of ammonia around furnaces directly after being blown out is, of course, well known. Sometimes enormous quantities are evolved, the odor being apparent until the entire lining is removed and the hearth cleaned out. The chief source of ammonia gas is undoubtedly the alkali cyanides and ammonium chloride which decompose in the hot water or water vapor introduced to cool down the furnace. In passing, it is

interesting to recall that a very small part of the cyanide produced in a furnace is fixed and carried down into the salamander in the form of the peculiar compound, titanium cyano-nitride. The excess accumulation of alkalis in the brickwork, or in salt deposits in a furnace lining after a campaign, may literally amount to several tons.

5. *By Evolution in the Gas.*—The heavy flue dust which is carried out of the top of the furnace by the gas current, of course, contains approximately its normal percentage of alkalis. The finer portions of ore, stone and coke dust doubtless average somewhat higher in alkali content than the entire materials as charged. All the remaining potash and soda in the burden, not previously accounted for, is sublimed and passes out in the form of various salts or compounds as a fine fume.

Various investigators have studied blast-furnace flue dust with special reference to its potash content, but almost entirely from a scientific standpoint. It is true that at least one American and one foreign patent have been issued for the recovery of potash in flue dust, but no evidence has been found that any practical application has thus far been made. And, so far as can be ascertained, the first commercial disposition of the flue dust as a fertilizer was made by us at Bethlehem somewhat more than two years ago.

The progress of the alkalis in our practice will now be traced from the furnace top, through the gas mains, washers, stoves, boilers and stacks.

ALKALIES IN DRY DUST BETWEEN FURNACE AND WASHER

Besides the dust carried out by the relatively small amount of gas escaping from the furnace top, and the insignificant quantity permanently deposited along the mains, all the dust under the above heading is removed from the dust catcher. Representative bi-weekly samples of the dust-catcher flue dust were taken over the same period during which the slag samples were secured and analyzed, showing the following averages:

	Total K ₂ O Na ₂ O	Water Soluble K ₂ O Na ₂ O
Average for all furnaces, first period.....	0.53 1.16	0.31 0.30
Average for all furnaces, second period.....	0.70 1.42	0.25 0.20
Average for all furnaces, both periods.....	0.61 1.29	0.28 0.25
Ratio average total potash to average total soda.....	1:2.1	
Ratio average water-sol. potash to average water-sol. soda.....	1:0.9	
Ratio average water-sol. potash to average total potash.....	1:2.2	
Ratio average water-sol. soda to average total soda.....	1:5.2	

A much greater percentage of the total potash than of soda is present in a water-soluble condition.

The entire absence of cyanides in this dust, and even in concentrated alkaline samples, recovered further along in the gas system, furnishes further corroboration of the fact that in normal operation practically no cyanide is carried in the gas current from the furnace top. That it may be an occasional constituent of flue dust, because of abnormal furnace conditions, is evidenced by several records at hand.

Tests made at different times show that our dust catchers remove an average of about 100 lb. of dust per ton of pig iron produced. Using the average percentage of alkalis in flue dust for the four weeks, we find:

	Pounds	Per Cent of Total Charged
Average potash in flue dust from dust catcher per ton of pig.....	0.6	1.8
Average soda in flue dust from dust catcher per ton of pig.....	1.3	2.3

EFFECT OF PRIMARY WASHERS ON ALKALIES IN DUST

At Bethlehem we have in service a type of tower spray washer, in common use in this country. All of the gas for stoves and boilers, as well as for gas engines, is

washed, except from one furnace. Naturally, it would be thought that practically all of the alkaline material in the dust, most of it readily soluble in water, would be removed in the wet washers. The bulk of it is washed out, but it is a remarkable fact that much of the water-soluble alkalis, remains in the gas current after leaving the washers. Calculations based on alkalis charged into the furnaces, lost in the slag, dust catcher, stack gases, etc., and recovered from the stoves and boiler settings, indicate that about 21 per cent of the total potash (apparently only about 5 per cent of the soda) entering the primary washers, passes through them. The explanation for this fact is that the particles of fume are in such an exceedingly fine state of division that they escape contact with the relatively large drops of water. In my opinion, any washer which will successfully clean blast-furnace gas rich in this fume must employ spray nozzles or other devices which will discharge water in a fine mist, thus insuring intimacy of contact between dust and water particles. Our washers at present perform the function of selective precipitation, eliminating the relatively coarse and heavy iron ore and coke particles, while delivering the lighter particles of dust and fume into the primary clean gas mains.

ALKALIES IN DIRT FROM PRIMARY CLEAN GAS MAINS

The mains carrying gas from the primary washers to stoves, boilers and secondary gas-cleaning plant accumulate dirt or mud gradually, and are washed out at intervals of every two or three months. This dirt is black when wet but after being dried is dark gray, and after the fine particles of coke dust are burned out, it is of a light-gray or reddish-white color. Sometimes drippings from a clean-out door along a gas main will form beautiful long stalactites. This material is in general appearance similar to the stalactites mentioned as exuding from the furnace shell. A typical sample was found to have the following proximate composition: SiO_2 , 0.28 per cent; $\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$, 0.68; CaO , trace; MgO , 0.25; K_2O , 44.63; Na_2O , 7.13; Cl , 37.22; CO_2 , 7.78; CN , trace; NH_3 , none. The almost utter absence of cyanide in this concentrated alkaline material is worthy of note.

ALKALINE DUST IN STOVES AND BOILER SETTINGS

The dark, wet dirt carried into the stoves, which at our plant are of the three-pass type, is dead burned, of course, the combustible or volatile constituents, etc., being expelled. The residue, in the form of an impalpable powder, collects to some extent in the bottom of the combustion chambers, a relatively large amount gathers in the bottom of the second and third pass checkers while the largest portion is carried out in the stack gases.

In the combustion chambers the dust frits together in friable masses. The accumulation is not great, the wells being cleaned out at intervals of about two months. However, the action on the brickwork is serious. All over the inner surface of the combustion-chamber walls, the lower surface of the dome, and the second pass checkers for a depth of several feet, a deep-green glaze is formed, or the brickwork is honeycombed. Along the fire-clay joints between the brick, the action is especially marked. Stove brick of a high silica content invariably glaze or slag, whereas those with a lower percentage of silica are more readily honeycombed or excoriated by the alkaline fume.

The thermal efficiency of the stoves is reduced, of course, by this glazing, erosive and honeycombing action, though repairs seldom have to be made during a furnace campaign.

The fine, light-colored dust, which accumulates in the

bottom of the second and third passes, is the material of commercial interest to us. It is cleaned out at intervals of three or four months. A typical pile of this dust freshly removed through one of the stove clean-out doors is shown in Fig. 1.

In the boiler houses the dust accumulates and is recovered every few days from the combustion chambers, from the passes and occasionally from the horizontal flues leading to the stacks. It becomes increasingly fine and richer in potash in its progress. The boiler tubes, of course, become coated with the dust and must be blown off with a steam or air lance.

The white fume continuously issuing from the top of the stove and boiler-house stacks is approximately of the same composition as that reclaimed in the last passes.

PROPERTIES AND QUANTITY OF ALKALINE DUST RECOVERED FOR SALE

As previously indicated, the dust recovered from the combustion chambers and stoves and boilers is a light, friable sinter, whereas the larger amount reclaimed from the passes and flues is in an exceedingly fine state of division. When drawn out of the stoves or boiler settings hot, it runs almost like quicksilver, but it absorbs a certain amount of water readily, and becomes somewhat clammy and heavy.

Sieve tests were attempted. By careful sifting, it was found that all of the alkaline dust would pass a 300-mesh sieve. It is a true fume. The small residues remaining on the various sieves, when examined under a magnifying glass, were found to be chiefly eroded brickwork.

Specific-gravity tests, also, cannot be made with accuracy. The lightest dust, without compression, will run well below 0.50 specific gravity. Samples taken from the checkerwork of five different stoves, and showing potash contents of 10 to 14 per cent, when tramped down gently in large glass measuring cylinders, showed the following varying densities: 0.68, 0.69, 0.73, 0.89, 0.96.

Knowing the exceedingly fine state of division and smooth, spherical nature of the ultimate particles in this fine fume, there is little cause for wonder that so much of it passes through a creditable wet washer untouched.

The water-soluble potash content of the dry, ignited dust, recovered from the stoves and boilers, having previously passed through the wet washers, will vary from about 5 to 20 per cent. Our practice has been to store the material in a large bin, capable of holding two or three carloads. The commercial recovery, begun in



FIG. 1—PILE OF DUST FROM STOVE

1914, was not thoroughly systematized until the ensuing spring. Thirty-six carloads, containing 1,073.5 tons with 106.3 tons of water-soluble potash, of alkaline dust shipped in the period of fifteen months, April 1, 1915, to July 1, 1916. This represents all the dust removed from stoves and boilers serving four 500-ton furnaces, which could be recovered in normal operation, without special effort. Instead of being dumped into a dirt car, the dust was simply emptied into a central bin. A number of other carloads of lower-grade material, contaminated by flue dust from unwashed gas, were also shipped from the other furnaces, but are not included in the above amount.

No readily volatile constituents, such as may occur in the unignited dust, of course, are to be found after roasting.

In general, the ratio of water-soluble to total potash is higher than in the case of soda.

The preponderance of both total and water-soluble potash over the corresponding soda determinations is impressive, showing the much greater removal of the latter in the wet washers, or its greater volatility, in which case it would be carried out of the stacks in greater quantity.

If we assume that the total soda content in the stove and boiler dust averages 40 per cent of the total potash content, and the water-soluble potash 80 per cent of the total potash, as appears reasonable from the foregoing analyses, then the total alkalis recovered in the fertilizer material in the above period is found to be:

Total potash	118 gross tons
Total soda	47 gross tons

Calculating on the basis of pig iron produced in the above fifteen-month period, the alkalis recovered in terms of total charged are as follows:

	Per Ton Pig. Pounds	Per Cent of Total Charged
Total potash recovered in fertilizer material 0.3	0.3	1.3
Total soda recovered in fertilizer material.. 0.1	0.1	0.3

The amount of potash recovered, though of considerable tonnage and value, is an insignificant percentage of the total charged.

At furnace plants using burdens rich in potash where the gas is unwashed, a considerable recovery still can be effected, though some precautions must be taken to avoid the coarser, raw flue dust. Several other furnace plants in the East, acting upon our suggestion, made directly or indirectly, have been recovering potash-bearing flue dust during the last year and a half.

ALKALINE DUST ESCAPING FROM STOVE AND BOILER-HOUSE STACKS

Some idea of the relative amount of alkalis discharged per unit value of gas from blast-furnace stove and boiler stacks may be gained by observing the color and depth of the fume. Dirty gas, of course, will obscure greatly the fine, white, alkaline fume. In Western practice, with washed gas, the escaping stack gases show a thin, white color. In our practice the stack fume is much heavier. At the plants in the Lebanon district, using Cornwall ore, the fume is relatively very dense.

About two years ago we made a series of tests, extending over a period of about a week, to determine the approximate amount of potash lost through our boiler-house stacks. The average results on the two largest stacks were as follows:

Average amount of dust per cubic foot, flue gas (62 deg. and 30 sec.), grains	0.12
Average percentage water-soluble K ₂ O in this dust	14.70
Average percentage total	18.60

Knowing the average volume of flue gas discharged, and the average volume of fuel gas consumed by the boiler houses, and produced by the furnaces, we can calculate roughly the weight of potash lost through the boiler-house stacks per ton of pig iron.

No actual tests have been made on potash losses from the stove stacks, but they should be slightly less per unit volume of fuel gas burned on account of the greater baffling action of the stove brickwork. We will assume these losses per unit volume of fuel gas to be 90 per cent as great as from the boiler-house stacks. The soda-potash ratios will be assumed to be the same as in the average stove dust.

	Per Ton Pig. Pounds	Per Cent of Total Charged
Total potash lost in boiler-house and stove-stack gases	2.6	11.2
Water-sol. potash lost in boiler-house and stove-stack gases	2.2	..
Total soda lost in boiler-house and stove-stack gases	1.1	2.8

ALKALIES LOST IN SECONDARY WET WASHER

A considerable percentage of the primary cleaned gas at Bethlehem is further cleaned in Theisen scrubbers for gas-engine use. Practically all of the fine dirt is thus removed, the small amount passing through the fine gas main and into the combustion chambers of the engines, having practically no cutting or scouring action, even when as much as 0.03 grain per cubic foot of gas is present. Samples of this dust, recovered near the engines, were of a smooth talcy consistency. The composition is similar to the finest stove dust.

The amount of alkalis recovered in the secondary scrubbers, per unit volume of gas, is practically the same as the sum of the alkalis precipitated in the stoves (or boiler passes) and escaping through the stacks. Knowing the gas-engine consumption of fuel gas, the alkalis removed in the wash water, calculated on the same basis as for the stoves and boilers, is readily found to be as follows:

	Per Ton Pig. Pounds	Per Cent of Total Charged
Total potash lost in secondary scrubbers.. 0.5	0.5	2.2
Total soda lost in secondary scrubbers.... 0.2	0.2	0.6

BALANCE SHEET FOR ALKALIES CHARGED, REMOVED AND LOST

Bearing in mind the extremely delicate nature of the problem, and the necessity for including a number of estimates, I will endeavor to summarize a rough balance sheet for alkalis, charged and produced in our average blast-furnace practice. Further, it will be remembered that this balance sheet is approximately representative of our local conditions only.

Apparently there is a greater loss of soda than of potash in the primary washer. This may be due to the greater solubility of the sodium salts, or to the larger size or possibly to the difference in contour of the fume particles of sodium compounds.

METHODS FOR FURTHER RECOVERY OF POTASH

In our present gas-cleaning practice, it appears that there is a loss in the primary washers alone of over half of the total potash charged, or about 12 lb. per ton of pig iron produced, though, as mentioned later, this amount is probably a little high. The amount recovered, while appreciable, and representing almost clear profit, is seen to be an insignificant part of the total, less than 1/2 per cent. Potash lost in the slag, around the shell and from the top of the furnace, for all practical purposes, is lost beyond recovery. The greater part of the alkali content of the flue dust removed from the dust catchers could be recovered by leaching in water,

TABLE VI—BALANCE SHEET FOR ALKALIES CHARGED, REMOVED AND LOST

	POTASH (K ₂ O)		SODA (Na ₂ O)	
	Pounds per Ton Pig Iron Produced	Per Cent Total Charged	Pounds per Ton Total Produced	Per Cent Total Charged
Total charged.....	22.4	.....	35.6	.....
Lost in slag.....	4.5	20.0	6.3	17.0
Lost in fume, etc., from iron and cinder notches, and shell (est. 10 per cent of slag loss).....	0.4	2.0	0.6	1.7
Lost in gases from top of furnace (est. 5 per cent total gas losses).....	0.9	3.9	1.4	4.1
Lost by combination with brick-work of furnace, stoves, etc.,.....	negligible	.....	negligible	.....
Recovered in dust-catcher dust.....	0.6	2.7	1.3	3.6
Lost in primary washers (est. by difference).....	12.5	55.9	24.6	69.5
Lost in secondary washers.....	0.5	2.2	0.2	0.6
Recovered in stove and boiler passes.....	0.3	1.3	0.1	0.3
Waste from mains, stoves and boilers (est. 30 per cent of quantity recovered).....	0.1	0.4	.....	0.1
Lost in stack gases.....	2.6	11.2	1.1	3.1
Total.....	22.4	100.0	35.6	100.0

but the percentage is too low to justify reclamation in this way. However, the potash now lost in wet washers and from stove and boiler-house stacks offers a legitimate and inviting field for its recovery. According to our balance sheet, it appears that about two-thirds of the total potash charged is now lost in the wash water and stack gases, or about 15 lb. per ton of pig iron produced.

About two years ago we obtained estimates for cost of recovery of the flue dust from several of our large boiler-house stacks, both by filtering and electrical precipitation methods; but the relatively high cost and the uncertainty in the potash market, deterred an actual installation. Later it was realized that the principal loss of potash was not from the stacks.

At intervals during the course of the last year or more, we have had in operation an experimental Cottrell electric dust precipitator, connected to the raw gas main leaving one of the dust catchers. It is not my purpose in this paper to discuss the operation of the unit, except to state that practically all the dust and fume entering the treater could be precipitated successfully. The color of the dust recovered varied from a light to a dark gray. Several samples were analyzed and showed a potash content of about 10 per cent. The total dust leaving the dust catcher is evidently very much richer in potash than the relatively heavy particles constituting the dust in the dust catchers. However, with the above knowledge at hand, and judging from check calculations on total dust leaving the dust catchers and its theoretical potash content (by difference), it is my opinion that the estimated weight (by difference) of potash lost in the primary washers is somewhat, though not greatly, too high. For our average practice, there should be not less than 12 lb. of total, and probably about 9 lb. of water-soluble potash, now lost in washers and stacks, per ton of pig iron produced.

It may be mentioned that by weak acid treatment part of the insoluble potash content in flue dust may be rendered water-soluble, though this is not likely to be of practical application. Also, the soluble alkali salts can be recovered in tolerably pure form by leaching and evaporation.

It is not my purpose to develop at length the commercial phase of the subject. With the foregoing figures and present potash-fertilizer value as a basis, anyone can readily determine what a very attractive proposition is the recovery of potash from blast-furnace gas at the present time. A word of caution may be appropriate. As previously indicated, the weight of potash

charged per unit of iron produced is above the average at Bethlehem. There are only two or three apparently practical methods for recovery on a large scale of potash from blast-furnace gas, and they are expensive and as yet untried for blast-furnace conditions. The price of potash is certain to fall after the war.

On the other hand, the recovery of potash in connection with the thorough dry cleaning of blast-furnace gas, with certain obvious advantages as against wet cleaning, is an attractive proposition to plants now suffering from burdens rich in alkalies. I venture to predict that in the future dry cleaning will be adopted in many blast-furnace plants, and that many thousands of tons of potash, hitherto wasted, will be reclaimed. Thus will our national resources be strengthened in this important raw material, and the blast furnace will have added another material to its increasing list of by-products.

The subject of alkalies in blast-furnace practice is of a difficult and complicated nature. It will afford much food for thought, both for the philosopher and the practical furnace operator.

Bethlehem Steel Company,
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Silica Brick and Some New Uses for Them

By Walter Gray, B. S.

Very little has been generally known about refractories and the adaptability of one kind of material over another for a particular class of work. Engineers have been very well satisfied if the refractory material would reasonably withstand the action of the flame and have not experimented, or investigated with a view of securing the most efficient and economical material. To the advent of the by-product coke oven in the United States is due much of the investigations of refractories which have been made. These experiments and others which have been conducted, indicate quite clearly the advantages of silica brick in many metallurgical and industrial operations. The investigations show that the field for the use of silica is not restricted, and that its adoption may in many cases prove a decided economy.

In order to secure a comprehensive idea of silica as well as its advantages and limitations, it is necessary to compare it with the other available commercial refractories. Such a comparison will show clearly the true worth of silica, and will indicate the probability of its success when substituted for another material. The common commercially available refractories are, magnesite, chrome, bauxite, clay brick, and silica brick.

MAGNESIA BRICK

Magnesia brick are manufactured from grain magnesite imported from Austria-Hungary which will analyze approximately 85 per cent MgO. The magnesite is quarried, carefully selected, crushed, and calcined at white heat (approximately 2900 deg. Fahr.) in shaft furnaces or rotary calciners. The calcined magnesite upon arrival in this country is tempered, ground with water, and made into brick without bond, and burned in down draft kilns at a temperature approximating cone No. 29. It is thus seen that the ordinary magnesia brick is the result of two burnings.

Magnesia brick have a very high fusing point, but soften and lose their coherence at high temperatures. This objectionable property restricts their use to operations where they will not be subjected to pressure at high temperatures. Magnesia brick expand rapidly and uniformly with an increase in temperature until the maximum is reached at about 2900 or 3000 deg. Fahr.,

where the softening effect is evident. Chemically magnesia brick are basic.

CHROME BRICK

Chrome brick are manufactured from chrome ore imported from Greece which will contain approximately 40 per cent Cr_2O_3 together with alumina, ferrous oxides, and silica. The ore is ground, formed into brick, and burned in down draft kilns. Chromium oxide is itself not fusible at metallurgical temperatures.

Chrome brick, however, due to the fact that there is but 40 per cent of the oxide present, soften at lower temperatures than magnesia brick and are consequently less strong and less resistant to deformation at high temperatures, and will often if loaded prove unreliable at temperatures above 2800 deg. Fahr. At lower temperatures chrome brick are dense and hard and stand abrasion well, but possess the objectionable feature of spawling with sudden changes of temperature.

Their chief value lies in their chemical neutrality, for chrome brick are neither acid, basic, reducing or oxidizing.

BAUXITE BRICK

Bauxite brick are manufactured from the alumina ore of the same name. Pure bauxite is light gray in color, but as it is generally found associated with impurities, the ore is generally red, yellow, or brown. Geologically it is regarded as decomposed basalt, chemically it is a hydrated alumina containing various quantities of aluminium silicate and hydrated oxides of iron.

In order to reduce shrinkage the bauxite has to be thoroughly calcined before being made up into brick and this materially increases the cost. In calcining, the material contracts little, until after the temperature has risen above 2390 deg. Fahr., when excessive shrinkage takes place, the maximum being reached at 2500 deg. Fahr. Water of combination to the amount of approximately 30 per cent of the weight of the raw ore is driven off.

The calcined material is mixed with from one-third to one-sixth part of plastic fire clay and with the addition of water is thoroughly worked and molded into brick and burned at the highest temperatures obtainable in the kiln.

Bauxite brick exhibit a highly basic tendency, the Al_2O_3 content running up as high as 55 per cent to 85 per cent. Although the fusing point of bauxite brick is very high, they have the objectionable property of cracking on sudden changes of temperature. By burning at the highest temperatures obtainable in the kilns, much of the shrinkage which was always detrimental to settings or linings made up of bauxite brick, has been done away with, and now bauxite brick are beginning to be used extensively.

FIRE CLAY BRICK

We are all more or less familiar with fire clays. Fire clays are the result of decomposition of igneous rocks high in feldspar, which, under the influence of weathering, result in kaolinite. Calcined kaolinite will analyze approximately 46.09 Al_2O_3 and 53.91 SiO_2 , and is representative of perfect fire clay. These kaolin deposits are stratified upon deposition, and are often subject to considerable pressure, which causes the clay to become hard and dense.

Chemically, fire clays are double silicates of alumina and consist of hydrous silicates of alumina, together with impurities in the form of iron, alkaline silicates, and water, either chemically combined, free, or both. Free silica in excess of the amount required to unite with the alumina will unite with the impurities, act as

a flux, and materially lower the fusing point. The alkaline content should be very low, not over 2 per cent, and the iron should be present in very small quantities, as 5 per cent will make the brick worthless. The amount of iron present is a direct indication of the fusibility of the brick.

The fire clays usually occur underneath the coal measures and require underground mining. The deposits consist of two kinds of clays—the hard flinty clays which are the heat resisting element in the brick, and the soft, plastic clays which form the bond. The hard or block clay, as it is called, very often occurs in the same vein with the soft clay, but is usually above the latter of less depth, and often not separated by any clearly defined line of demarkation. This relationship may reverse itself both as to position and quantity, and sometimes the two are even intermingled. The clays when mined are broken by a hammer, carefully selected, and stocked in piles. The proper proportions of crushed lean and plastic clays, together with "grog," the trade name for ground brick, or calcined clay, are ground in the wet pan with sufficient water to give the required consistency and molded into bricks. When worked between the thumb and finger, it gives a decided sticky feel. The shapes are dried bone dry on a hot floor or in a dryer, and are burned in down-draft kilns at a temperature approximately 2500 deg. Fahr.

SILICA BRICK

Before the advent of silica brick, natural siliceous rocks such as sandstones, granites, gneiss, and quartz porphyry had been quarried, carefully dressed, and used as refractory linings. Even at the present time mica schist is still extensively quarried for use in lime kilns. The use of such rocks, however, was not altogether satisfactory; due to physical defects and exfoliation, they suffer severely from the action of the heat. The introduction of silica brick followed quite naturally, for a light uniform shape easily handled and easily laid had everything in its favor, and speedily superseded the natural rock.

RAW MATERIAL

Silica brick are manufactured from a sandstone or quartzite which is of sedimentary origin. On account of certain physical features which are very necessary for the manufacture of a well-bonded brick, brick manufacturers are restricted in the selection of their raw material to certain parts of Pennsylvania and Wisconsin and Alabama. For the successful manufacture of brick the siliceous material must be in the form of a rock and not a sand or gravel. The rock should be hard, dense, metamorphic, and semi-crystalline in structure, not granular, with little indications of lime, talc or clay, and with little discoloration from iron. When ground, the grains should appear splintery, sharp, heterogeneous as to form and size, and slightly translucent. It is the physical roughness of the material that gives the brick its strength. The more homogeneously knit together the grains are which compose a brick the better service it will give. Pure quartz, rounded pebbles, or grains of sand, or too coarse crystals prove undesirable as they will not bond tightly. In gneiss rock, such as silica brick are made from, the cementing element is as hard as the quartz grains, and upon grinding the particles do not become rounded, but interlock in the brick and bond well.

A suitable quartzite should analyze approximately 97.5 SiO_2 , 1 per cent to $1\frac{1}{2}$ per cent Al_2O_3 , 0.75 per cent other impurities, smelt at cone 35 to 36, expand, and swell without perceptible cracking. The total fluxes should not exceed 3 per cent. Alumina, if in the form of kaolin

or a silicate, should probably be not higher than $1\frac{1}{2}$ to 2 per cent.

QUARTZITE

In America we have to distinguish between two kinds of silica refractories: First, brick high in silica, known as ganister or lime-bond silica brick, in which the bonding agent is lime; second, brick lower in silica, known as quartzite, in which clay is the bond used. Although not so strong physically as the clay brick, quartzite possesses the advantage of being easily worked and expands with increases of temperature, but in a much less degree than silica. Quartzite brick will analyze approximately 70 to 75 per cent SiO_2 and 21 to 26 per cent Al_2O_3 . They are manufactured by adding approximately one part of fine ground clay to two parts of crushed quartz, mixing with water and forming into brick.

MANUFACTURE OF SILICA BRICK

The two most important deposits of ganister, the trade name for silica rock, best suited for the manufacture of silica brick are found in the Mount Union district of Pennsylvania and the Baraboo region of Wisconsin. The Mount Union rock is fine grained, grayish white in color with tinges of yellow, and showing slight discoloration from iron. The Wisconsin quartzite is much darker in color due to a larger content of iron, and seems much more crystalline in structure. It is denser and harder to work than the Mount Union rock, and has evidently been subjected to a greater pressure, with perhaps some heat. The ganister rock found in the South near Birmingham, Ala., resembles very closely the Mount Union rock, both in its physical and chemical properties. These various rocks will analyze approximately as follows:

SiO_2	0.98%	Lime	0.20%
Al_2O_3	0.60%	MgO	0.10%
Fe_2O_3	0.70%	Alkalies	0.40%

Silica rock is almost never mined at depth, but as in the case of the Mount Union district is collected in the form of boulders and fragmentary pieces which have been torn from the parent ledges and strewn over the surrounding territory, sometimes to a depth of 4 ft. or even considerably more, or else it is quarried from the shelves or ledges. When too large these boulders are shattered by blasting and the fragmentary pieces are carefully examined for impurities, and all ferruginous, calcareous or argillaceous rock are rejected. The rock is then transported to large open yards. When required for the manufacture of brick it is crushed to a suitable size in gyratory or jaw crushers. The broken material is then conveyed in buggies to the wet pan, and ground beneath the rollers by a few revolutions of the pan before the milk of lime is added. Only pure soft white lime manufactured from limestones high in calcium carbonate is used. The lime is mixed with the proper quantity of water stored in tubs and fed in proper proportions into the wet pan, usually 2 per cent by weight, and the grinding resumed. Great care is taken to see that the right proportion of lime is added so that it will produce a well-bonded, hard-ringing, clinkered brick. In analysis the lime will often show up as 1.75 per cent, due to losses, but great care is taken that never more than 2 per cent is added, as a material reduction in refractoriness would result.

The material, when ground sufficiently fine, is but slightly damp and, unlike the clays, possesses practically no plasticity, and when worked between the thumb and fingers resembles in feel and appearance moist fine sand. To the trained sense of touch there is a considerable difference in the feel of the material from the different pans, due altogether to the manner in which water has been added and the material worked. The moulder

who receives the ground mixture pounds and works it into the mould with his fingers and trowels it smooth. The moulds are of steel, and make several brick, depending on their size, at the one operation. A steel plate which forms the shelf in a rack car also forms the bottom of the mould, and when the mould is withdrawn it carries the shapes. The rack cars are run to the dryer, or in the case of larger shapes to the hot floor. The drying takes approximately ten to twenty hours, depending, of course, on the size of the shape. Large shapes are laid on the hot floors and turned from time to time. Difficult shapes are less often made in silica than in clay, due in a large measure to the great care required in drying them to prevent cracking, and due also to the lack of plasticity of the material.

The brick are stacked with great care in the kiln, the ordinary standard shapes being placed on edge and bonded at intervals with burned bats. Openings somewhat on the order of checkerwork are left through which the flame can pass and escape through the riddle flues in the floor. The brick are protected from fire flashing by a checkerwork of burned bats built around the firebox. Great care is observed in the setting of the shapes so that they will not only be subjected to the required temperature, but will also sustain the load and not allow a slip to occur, which might prove detrimental to the entire charge. Difficult shapes because of their size or fragility are generally carefully placed high in the kiln where they will have to carry but little weight. The kilns are usually round kilns of the down-draft system, fired with coal, and will hold, depending on their size, anywhere from 30,000 to 100,000 brick at a single firing.

The operation of burning may be divided into three periods. During the first period the brick are thoroughly dried and the moisture removed. This is necessarily a very slow process and cannot well be hastened. Three days are required to drive off the moisture, the temperature gradually being raised to approximately 300 deg. Fahr. Considerable air is admitted throughout this stage of the drying. During the intermediate period, which will last for approximately four days, the temperature is gradually increased and the draft steadily diminished. The carbon dioxide passes off from the lime and the oxidation of any ferrous iron to the ferric condition occurs.

During the burning proper, which forms the third period, the clinker is formed. This clinker is the slag produced by the combination of the lime with the silica. This is a lime silicate, but its character is made more complex by the addition of the Al_2O_3 and the Fe_2O_3 , which occur in the brick, and unite in forming the slag. This slag glazes over and binds the particles of quartz, and in shrinking makes the brick porous and produces the property of clinkering or producing a ringing sound when struck. During the burning period there is but very little excess air allowed in the kiln, and the temperature is forced up to 2800 deg. or 3000 deg. Fahr. and the brick kept at a soaking heat for three to four days. The final temperature should always be higher than the temperature the brick are to encounter in actual practice. When the brick in the kiln have been kept at the required temperature as indicated by Seger cones for a sufficient time, the dampers are closed, the fires are allowed to die out and the kiln allowed to cool off. Great care is observed to prevent drafts of cold air from striking the heated brick. The kiln necessarily cools very slowly, and ordinarily it is two days after the fires have been extinguished before the kiln can be opened. Four or five days more elapse before the brick are sufficiently cool to handle and sort and wheel to the storage sheds for shipment.

PROPERTIES OF SILICA BRICK

Very little real scientific investigation has been made with a view of determining the physical properties of firebrick. Many manufacturers have used only a thumb-and-rule method in making their brick, and have secured satisfactory results more by good luck than good management. Indeed, so content have they been with this haphazard system that they have looked upon all experiments in the research laboratory as interesting but not essential, and far too expensive.

Keen competition and the increasing use of refractory materials in many new industrial operations have caused the brick manufacturer in recent years to study his product with a view of determining the adaptability of one refractory over another for a particular class of work. Indeed, the manufacturers are just beginning to realize that the question of refractoriness, vital as it is, is not always the all-important one. Expansion, abrasion, conductivity, and especially the ability of the material to withstand pressure at operating temperatures, must be considered if a highly efficient and economical material is to be produced. It is only within the last few years, with the widespread adoption of the by-product coke oven, that the very important questions of expansion and conductivity have been seriously considered.

La Société d'Encouragement pour l'Industrie Nationale of France, believing that a more comprehensive knowledge of the properties of refractories would be of inestimable value, granted S. Wologdine a research scholarship and placed laboratories at his disposal. With this and one or two other exceptions such experiments as have been made have as a rule been conducted by the brick manufacturers themselves.

CHEMICAL PROPERTIES

In general, the chemical analysis gives a very good indication of the quality and refractoriness of a brick. The actual fusing point, however, is dependent also in a large measure on the size of the grains, the homogeneity of the mass, the burn, and the mineral elements which comprise the brick. However, in silica, a chemical analysis is of very great importance, as the refractoriness depends directly upon the amount of lime, alkalies and iron present. The silica content should be about 96 per cent, the lime $1\frac{3}{4}$ per cent to 2 per cent, and the alumina and iron about $1\frac{1}{2}$ to 2 per cent. As a matter of fact, silica brick will analyze approximately as follows:

SiO ₂	96.0%	Lime	1.75%
Al ₂ O ₃	0.90%	MgO	0.14%
Fe ₂ O ₃	0.70%	Alkalies	0.39%

Possibly it would be well to explain here the seemingly inconsistent statement that a high-alumina, low-silica firebrick is more refractory than a brick comparatively high in silica, and that a lime-bond silica brick is the equal or superior of a high-alumina fire clay brick. This is explained by the fact that the alumina and silica, which unite to form the alumina silicates of clay brick, are capable of combining in almost any proportion from 1 molecule of alumina to 2 molecules of silica, or from 1 molecule of alumina to 17 molecules of silica (10 alumina to 90 silica by weight). Seger made several tests using cones composed of various proportions of chemically pure precipitated alumina and silica, increasing the silica in multiples of one part of alumina. This relative increase of silica added to one part of alumina was used as ordinates, and the various Seger cones, indicating temperature, were used as abscissæ to plot a curve which would graphically show the fusing point for any combination.

The maximum refractoriness, as indicated by the

highest fusing temperature, is 1 molecule of alumina and 2 molecules of silica which fused at approximately cone No. 37 (3393 deg. Fahr.). The curve drops as we continue adding silica until at about 17 parts silica to 1 of alumina the fusing point is indicated at approximately 3160 deg. Fahr. by cone No. 29. This is the eutectic point of the curve, for as silica is further in-

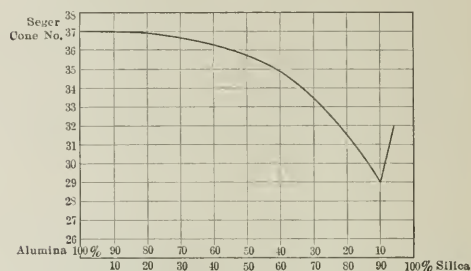


FIG. 1.—CURVE SHOWING EFFECT OF ADDITION OF SILICA TO ALUMINA

creased the refractoriness rises until with the proportion of 30 silica and 1 alumina a fusing point of 3300 deg. Fahr. is obtained.

These results are due to the fact that an excess of silica in a clay brick is present in the form of quartz, and acts as an impurity and tends as all impurities do to depress the refractoriness. The curve shows us that we may expect maximum refractoriness in a high alumina brick, such as bauxite, and also in a high silica brick, such as lime-bond silica, and lower refractoriness in a combination of alumina and silica, as in the case of quartzite, which has closely the proportions of alumina and silica referred to as cone No. 17.

Silica, the opposite of magnesia, is acid, and is used in metallurgical furnaces operating with acid slags to form a stable lining. It is very soluble in strong alkaline solutions, easily attacked by metal oxides and flue dust.

PHYSICAL PROPERTIES

Refractories naturally group themselves into acid, basic and neutral materials, and it is, of course, obvious that where a slag is to be encountered its chemical nature determines to a large extent the refractory material to be used. In other operations, where such limiting conditions do not exist, or at least only in a slight measure, an investigation of the physical properties of the refractories material will assist in determining the best brick to use.

Silica brick are straw colored, smooth of surface, with sharp, well-moulded corners, and present upon breaking a coarse crystalline fracture, discolored occasionally by reddish-brown spots showing the presence of iron oxide. These spots may be due either to iron naturally contained in the rock or may result from the oxidation of small pieces of metallic iron which has been worn from the pan rolls or crusher jaws and been incorporated in the brick.

A 9-in. straight weighs almost exactly 6 lb. and has a specific gravity of 2.4, is quite porous, brittle, and not easily worked.

Silica brick are the ideal brick to use where a high and constant temperature is to be encountered, and where the chemical action of the slag is not detrimental. Silica, however, possesses the objectionable feature of sprawling or disintegrating if subjected to blasts of cold air or irregular cooling when hot. Great care should always be exercised to bring silica brick up to

their working temperature slowly and evenly, for not only does too rapid heating cause excessive spawling, but materially lowers the refractoriness of the brick.

After the original heating, the brick become annealed somewhat, and such great care is not necessary. Indeed, the abuse that silica brick will stand after proper treatment in the original firing is wonderful. Silica brick, like chrome and magnesia, expand when heated, and for this reason are of great value when used in domes or arches or gas-tight chambers, as in expanding they tend to keep everything tight and in alignment. Fire clay brick, on the other hand, contrary to popular belief, expand a slight amount upon heating, but shrink very considerably when cooled, and the fire clay with which they are laid may shrink so much that it opens up the joints and allows the brickwork to settle badly. Silica, even if badly cracked and checked, expands sufficiently to keep the structure tight and in position. Furthermore, silica brick retain their shape and refractoriness practically to the point of fusion, and are capable of supporting loads of 75 lb. per square inch or more at temperatures well above 2700 deg. Fahr. or 2800 deg. Fahr. Magnesia and chrome brick, it will be recalled, soften, and are subject to considerable deformation at high temperatures, while a fire clay brick, if submitted to such a test, would deteriorate and squeeze out of shape.

With standard brick there is no distinction made in regard to grind or burn, as is the case with clay. In shape work the grind is usually finer to insure a more perfect filling of the mould and produce a better appearing shape. The fineness of the grind making a more intimate mixture of the lime and silica resulting in a better slagging effect will increase the strength of the brick. Silica brick are considerable more refractory than clay brick, although not as refractory as chrome or magnesia. They will not melt at temperatures under approximately 3400 deg. Fahr., as compared with 3900 deg. Fahr. for magnesia and 4000 deg. Fahr. for chrome. In silica brick the softening and fusing points are almost identical.

Expansion.—Standard 9-in. silica brick will expand as much as $\frac{1}{8}$ to $\frac{1}{4}$ in. in length and $\frac{1}{8}$ to $\frac{3}{16}$ other dimensions in burning in the kiln, from the green shape to the commercial brick. This increase in volume is accounted for by, first, an increase in the size and number of the pores; second, an expansion of the mineral itself, and, third, the change of the quartz into tridymite. At approximately 1050 deg. Fahr. quartz goes into another crystalline form, then into betaquartz, and at 1800 deg. Fahr. in to tridymite, remaining in this form between 1800 deg. and 2900 deg. Fahr. According to one authority this transformation is accompanied, in the case of a pure quartz, by an increase in volume of approximately 10 per cent. In an ordinary brick, it is believed by many that only one-third to one-half of the whole amount of quartz present has been changed into tridymite, and that the remainder is changed more slowly in the furnace. However this may be, it is always the brick manufacturer's aim to burn all the expansion out of the brick in the kiln, but such a state of equilibrium is never reached. A good silica brick should show a considerable expansion on first burning and a relatively small expansion thereafter.

Porosity.—The test for porosity is made by heating the brick to expel all moisture and weighing it, then immersing it in boiling water for several hours, allowing all included air to escape. The difference in weight before and after immersion is a direct indication of the porosity. Silica brick in test will show a porosity of 10 per cent by weight and 20 per cent by volume after immersion for several hours in boiling water.

They are generally more porous than quartzite or clay brick.

Density.—The density varies with high temperatures, diminishing as the temperature is increased proportionally to the contraction in the pore space. In the case of silica Wologdine found the density decreased regularly until at 2500 deg. or 2600 deg. Fahr. it was approximately 2.57. This decrease in density is accompanied by only a slight change in porosity. Pure magnesia, on the other hand, shows a marked change in porosity. This change decreases, however, instead of increases, as in the case of silica. The higher the brick is in impurities the lower is the temperature at which the drop in specific gravity becomes manifest. It is evident that a curve correlating burning temperature and density will give a very good expression of the refractory qualities of the brick.

Permeability.—As a general proposition the heat conductivity of fire clay and silica refractories is that of the air enclosed in the pores, and not that of the material itself. From this it is evident that conductivity and permeability increase with the porosity and vice versa. It is also evident that the size of the grain and other physical conditions will influence the permeability, the most noticeable of these being the burning temperature. Wologdine discovered that silica brick burned at 1050 deg. C. and had a permeability of 3.3 liters per hour, but at 1300 deg. C. their permeability had increased to 192 liters, and at 1400 deg. C. to 241 liters per hour. This shows that the permeability may vary in a very marked degree, while the other physical properties may change but slightly with the increase of temperature. This is accounted for by the great change in pores and capillary openings due to the transformation of the silica during vitrification.

Conductivity.—It is very much to be regretted that the information which is available on this property of refractories is limited to low temperatures. As heat conductivity increases quite rapidly with an increase in temperature, the importance of information on conductivity at operating temperatures is obvious. Experimenters have been limited by the great difficulties of measuring heat at such high temperatures and the physical limitations of the apparatus used. The experiments which have been made have employed temperatures usually not exceeding 400 deg. or 500 deg. Fahr., and only in rare cases have higher temperatures approaching the working condition of the refractory been used. Wologdine reached temperatures of 1000 deg. to 1200 deg. C. in the experiments that he made.

The results of a rather interesting experiment showed that to melt paraffine by heat conducted through $4\frac{1}{2}$ in. of brickwork 48 minutes were required for clay brick, 45 minutes for quartzite, 39 minutes for silica, $32\frac{1}{2}$ minutes for chrome and $17\frac{3}{4}$ minutes for magnesia brick. Another test, using, however, rather low temperatures, showed magnesia to possess the greatest conductivity, with chrome second and silica third, and the clay brick following in sequence in the order of their densities, the lighter densities showing the higher conductivity.

From this, as stated above, we infer that conductivity is a direct function of the density. Density, it will be recalled, is dependent upon the fineness of the grains and the temperatures of burning. It has been shown by experiment that the conductivity of firebrick increases with the temperature of burning; that is, the higher the burning temperature the greater the conductivity. Wologdine found a unique exception to this rule to be chromite, the heat conductivity of this material being independent of temperature. Silica has approximately 20 per cent greater conductivity than clay

brick, whereas the conductivity of magnesia is double that of clay. The increase of conductivity will vary considerably. Wologdine found that bauxite brick increased one and a half times in conductivity when burned at 1300 deg. C., as against 1050 deg. C., whereas in the same range of 250 deg. C. magnesia showed an increase of but 5 per cent.

Load Test.—It is generally conceded that the load test is the fairest criterion of refractories. Its chief advantage lies in the fact that it will give a very adequate idea of the behavior of a refractory under operating conditions. Other tests do not always include such considerations. A brick which may show high compressive strength at atmospheric temperatures may fail utterly or possess only a small portion of this strength at high temperatures. A compressive test on cold brick is desirable, but aside from the fact that a weak brick is always a handicap, such a test gives practically no information regarding its resistance to deformation at high temperatures. The load should be somewhat greater than actual furnace loads, as in tests the time element, which is a very vital factor in actual operation, cannot receive attention.

The brick are either loaded singly or built into columns. In either case they are carefully measured in order to calculate the shrinkage and deformation. The results of many tests show that silica is the only brick which will support its own weight, or a reasonable load, without deformation at high temperatures. Quartzite and clay brick begin to show settling at temperatures approximately 400 deg. to 500 deg. Fahr. lower than the temperature at which they were burned. Quartzite brick settle rapidly out of shape from their own weight at temperatures approximating 2700 deg. Fahr. It is evident from this that the range between the softening and fusing points decreases, as the silica contents of a clay brick increase. Silica brick usually show in such tests, especially if built in columns, an increase in height, due to expansion, whereas the clay brick column will show a shrinkage of almost 5 per cent of its original height and the bricks will be fused together. As an illustration, the results of a typical test might be mentioned. Columns were built of silica, quartzite and clay brick, loaded and heated to high temperatures. The silica column supported a weight of 75 lb. per square inch, was subjected to a temperature of 3200 deg. Fahr., and was in good condition at the completion of the test. A similar column made up of clay brick heated to 3100 deg. Fahr. and supporting a load of only 27 lb. per square inch suffered bad deformation. The quartzite column under similar conditions did not prove as reliable as the clay brick.

By plotting a series of failing loads against the chemical impurities in the brick a very good idea can be obtained of the manner in which these impurities affect the refractoriness and resistance to deformation, for it is due to their presence resulting in low fusing points that the test pieces fail.

Special Uses of Silica Brick

In calling attention to special uses of silica brick, no claim is made that they will prove a panacea for all the troubles and shortcomings experienced with refractories used in similar metallurgical and industrial practice. Whether or not silica would answer equally well in other operations and under other conditions than the cases to be described is something which only careful study and experiment can determine. Much of the information given was secured from the Harbison Walker Refractories Company. The cases cited are from actual practice and the results described are the observations of operators and men who have been in actual touch

with the plants and conditions under which these silica brick have been used.

In presenting these special uses of silica brick, the only claim that is made is that satisfactory results have been secured from them in the particular uses to which they were put, and that they have in many cases proven an economical substitute. These results, because of their uncommon interest, justify their incorporation in this paper.

OPEN-HEARTH CHECKERS

It is interesting to note that the use of silica in open-hearth furnace construction is continually increasing. Formerly the checkerwork was composed entirely of clay brick, and often of not any too good quality. Some steel plants have found it advantageous to use a few courses of silica brick upon the top courses of the checkers. Even the best clay brick when used here fuse and become vitrified. The carbon and particles of slag and limestone carried over by the flue gases permeate and coat them, destroying in a large measure their ability to absorb and give off heat readily.

Silica brick, it is claimed, are less readily choked up, as the carbon coating does not seem to penetrate them and adhere as in the case of clay brick. As they do not fuse or vitrify, being sufficiently refractory to withstand the heat, they not only give many times the life of clay brick, but can be used over several times. Indeed, so favorably have they proven for this class of work that many open-hearth plants are making all their checkerwork of silica, with the exception of the last few courses, which would be subject to spawling due to sudden and wide variations in temperature. Not only is the load on the girder arches considerably less, because of the lighter weight of silica brick, but it is claimed that due to its higher porosity and conductivity the use of silica exerts a marked influence on the quick working of the furnace.

BOILER FURNACES

Silica brick have rarely been used in boiler settings and coking arches. Their objectionable property of spawling when struck by a draft of cold air would make them almost prohibitive in such a practice.

They have, however, been tried, and in one or two cases where they were protected from drafts of cold air, and where the heating was gradual and the boilers were not forced, they have given satisfaction and have outlived clay brick, and been quite free from clinkers.

In this connection, it is interesting to note that bauxite brick are being tried in boiler furnaces with gratifying results. They are particularly free from clinkers, such as form on clay brick. Like silica, however, they have a tendency to sprawl on sudden changes of temperature.

BEEHIVE COKE OVENS

The use of lime-bond silica brick for the crowns of coke ovens is not new, but possesses some very interesting features. Here we see silica used under conditions which seem most detrimental to its success.

In the original firing some care may be observed in heating the ovens up gradually, but the very nature of coke manufacture makes almost any such attention subsequently impossible. Drawing the oven when at its highest temperature, leaving it to cool very quickly with drafts of cold air impinging on the brickwork, exerts a very detrimental influence. An examination of any coke oven crown will show that the brick have spawled and cracked very badly due to the severe treatment received. However, the expansion of the silica and the taper of the brick retains the pieces in the dome.

When once the crown has become cracked or parted throughout, so that the tendency to spawl is reduced to a minimum, and the brick have become annealed, the crown may be good for a great many years. It seems strange that silica brick used under most trying conditions should be the only satisfactory material for this purpose. Their universal adoption is sufficient proof of their value, as against clay brick, the best of which does not seem able to withstand the high heats for any length of time, but slowly melts and runs, and finally falls from the setting.

LIME KILNS

The use of silica brick in the construction of lime kilns is a new departure. On account of its refractoriness and proximity, mica schist has been used extensively for the eyes and piers of lime kilns; indeed, many lime burners say it cannot be excelled. Silica brick, on account of the ease with which they can be moulded into any shape or form and handled, are being tried out by quite a few large lime companies as a substitute for mica schist. The use of silica as a lining material for burning lime may seem paradoxical and contrary to the axioms of chemistry, but when the fact that lime and silica do not combine to form a silicate at the temperatures at which the lime is burned is considered, its use does not seem so unreasonable.

Silica brick have been used generally in the barrel of the kilns, and extend anywhere from a few courses above the eyes to as much as 15 ft. above the arches, the remainder of the stack being clay brick. It is in the barrel of the kiln that the severest action takes place. The hot limestone, when it has worked down this low in the kiln, is semi-plastic and soft and hangs in the shaft concentrating the heat and burning out the lining. The eyes are located at this portion of the kiln and are the weakest point in its construction. They are subjected not only to the intense heat of the fuel and the hot stone, but also to the detrimental effects of drafts of cold air striking the heated brickwork every time the firebox doors are opened.

The kilns of eight large lime companies widely separate, who were probably the first to use silica with any degree of thoroughness, have been selected as representing the most reliable sources of information. Four of these companies manufacture high calcium lime and the other four make a high magnesia lime. Of the high calcium kilns, one is rotary and gas fired, the remainder are of the vertical shaft type and coal fired.

In the rotary kiln silica is used in the hot zone to replace high-grade fire clay and chrome brick, resulting in an increased average life of twelve months, as against a previously maximum of three months. The vertical kilns are lined in the barrel, and in the arches and piers with silica brick.

With the exception of one kiln, in which the heats were brought up in two hours and no care had been exercised in first firing, the results from using silica brick are most gratifying. One company that is securing approximately twice the life from silica that they had secured from high-grade clay observed great care in firing their kilns. The heats were brought up very gradually for the first twelve hours, and only attained their full intensity after thirty-six hours. After this first firing, however, the silica linings are treated with no more care than ordinary clay brick. In twelve months' service the piers in the kiln had been reduced in cross-section only 25 per cent, due to direct impact of the flame and severe service.

Of the four kilns-producing high magnesia lime, but one of them (which is rectangular in shape) is producer-gas fired. It is lined with silica brick in the eyes and

barrel and promises to outlast any previous clay lining. All the other kilns are coal fired. In one kiln, in which silica brick has replaced the arches and jambs, formerly made of mica schist, it gives considerable better life at approximately half the cost, and has proven so satisfactory that this company intends using it in five other kilns.

The largest of these companies, manufacturing high magnesia lime, has one kiln of the Eldred system which was first fired in April, 1911. It is lined in the eyes and barrel with silica brick and has now been in operation for two years and is in such condition that with some minor repairs to the arches, due to sprawling, it may last for a much longer period. The decision of this company to line four more kilns with silica brick is conclusive proof of satisfactory results.

An interesting feature of the use of silica brick at this plant was the failure of the lime to stick or hang, it is claimed, so that considerable of it passed through under-burned, causing a decrease in capacity of approximately 8 per cent a year. This is undoubtedly due to the exceptional refractoriness of silica brick and its failure to in any way flux with the calcining lime. On clay brick the lime will often clinker, forming "monkeys," which in breaking loose tear the brick out with them. By corbelling the brickwork so as to give a purchase for the descending lime this trouble was obliterated, and there has been no recurrence of it either here or at any other plant.

These results indicate that the use of silica brick may mean a decided increase in the life of the kiln lining and result in a considerable economy in operation. Where failures have occurred they can almost always be traced back to injudicious management and poor handling. Where the best results are to be obtained great care must be exercised in the initial heating. The temperature should be brought up gradually and slowly, especially for the first 600 or 800 deg., as it is in the first heating that there is so much danger of spawling. After having been well tempered, silica brick will stand an extraordinary amount of abuse.

CUPOLAS

The use of silica brick in cupolas is as interesting as it is unique and uncommon. There are but two or three such cases which have come to the writer's notice.

One company which manufactures steel castings has been using silica brick in its cupolas and for lining its ladles for some four years, and with marked success. This company uses about four or five courses of silica brick in the melting zone of its cupola, and backs them up with standard clay firebrick. The brick are laid tight in silica cement and no extraordinary allowances are made for expansion. In lining its Tronepas converters, however, a space of an inch and a half is allowed against the shell for packing and expansion. No serious trouble has been experienced due to spawling, as the heats are increased slowly. The cupolas are, however, shut down cold each day after a run of ten hours, and in quenching the charge no great pains are taken to prevent the steam from striking the heated brickwork. No accurate records have been kept by this company regarding the life of silica brick, but it is roughly estimated as three to one in favor of silica against high-grade clay, and it is believed this estimate is very conservative.

The ladles used by this company are lined entirely with silica brick, with the exception of the top courses, which are clay brick, as silica would spawl badly at this point, where the hot metal and the atmosphere both react on the brickwork. The linings show a tendency to spawl if heated too suddenly on the first pour. After

a few heats, however, the brick become slightly glazed over, due to the action of the hot metal and the slag, and receive such a hard durable surface that no further trouble is experienced, no matter how quickly the ladles are heated. Each ladle is used for approximately fifteen heats of 5000 lb. each. The life of silica in these ladles is approximately seven times as great as the life of the clay brick formerly used.

Another company, which on a test secured four weeks' longer life with silica than with any clay brick previously used, have relined their cupola stacks for quite a way up with silica brick. Although the brick have been in but for a short time, they are getting twice the life secured from any clay brick formerly used.

BY-PRODUCT COKE OVENS AND GAS RETORTS

Silica has almost entirely replaced quartzite and clay bricks in by-product coke ovens and gas-retort settings. The rapid development of the by-product oven and the thorough investigations and experiments carried on by expert engineers are responsible in a very large measure for the adoption of silica brick. Indeed, the progress which has been made and the results which have been secured are attributed directly by the oven builders to the use of silica.

The physical limitations of clay or quartzite brick do not make their use desirable. In order to secure a high-grade coke, it is important that the chambers should be heated uniformly, and that the coking temperature be high and the time of coking short. It has been found that to decrease the duration of coking has resulted in a much better grade of coke. Also gas of high candle-power is produced in a retort if the charge of coal is large, leaving a minimum amount of retort surface to act upon the gas as it is generated, and if the temperature of the retort is high, resulting in rapid gasification. The hydrocarbons are thus made permanent gases and the tendency to dissociation into other forms of hydrocarbons of lower candle-power minimized. The heavier charges and shorter periods of carbonization have required heats far in excess of that which the old clay retort could stand. Such temperatures as are now employed approach the softening point of clay, and would cause excessive shrinkage and deformation in the old style clay retorts.

The ability of silica brick to stand up and retain their shape at the temperatures encountered in modern gas retorts and by-product coke ovens has made possible the high state of development to which they have been brought. Silica coke oven or retort shapes keep their alignment and neither sag nor bulge. They give considerably longer life than clay shapes and do not have to be renewed so often. As silica has approximately 20 per cent greater conductivity than clay the temperature inside the retort or oven is higher and the time for the distillation of the volatile matter considerably less. The higher the heats, the greater output and the shorter coking time results in a fewer number of benches or ovens for the same plant capacity as compared to clay linings. The expansion of silica brick is a very valuable feature, for if it were not for this property it is doubtful, with sectional retorts and long coking chambers, whether small shapes could be used at all. It is certain, that the expansion tends to keep everything gas tight. In laying the shapes, this expansion is usually taken care of by paper joints. Silica retorts and ovens are not only particularly free from clinkers, but the carbon deposits do not seem to penetrate them as is the case with clay. This results not only in increased heat transference, but saves the brick from severe scarring action in cleaning, and as the necessity for cleaning is

reduced, the retorts or ovens will be out of commission less frequently.

Actual comparisons between the life of clay and silica in by-product coke ovens are not at hand, but it is a well known fact that silica will give many times the life of clay and in addition prove a great economy in operation. In the case of gas retorts, however, we have a very good comparison. Mr. Samson, in a paper presented before the fourth annual meeting of the American Gas Engineers' Society, described the advantages secured from the installation of silica retorts at the plant of the Worcester Gas Works. The test was made with the same kind of coal which had previously been used in the clay retorts. In the old clay retorts, which were 16 in. x 26 in. x 10 ft., 1 lb. of Westmoreland coal when coked gave 4.95 cu. ft. of 14 cp. gas—practically 70 candle feet. The new silica retorts, which are 26 in. x 26 in. x 17 ft., produced 5.95 cu. ft. of 17 cp.—practically 101 candle feet, from a pound of the same coal. Figures such as these need no further comment; they are themselves conclusive proof of the superiority of silica brick for gas retorts.

CONCLUSION

The cases which have been cited involving special or new uses for silica brick are quite representative and cover a wide range of industries using refractory materials. They show quite clearly that the uses of silica brick are by no means restricted. Indeed, it would seem that the advantages and properties of silica are just beginning to be appreciated and that it is only a question of time until silica will replace clay brick in many industries in which it has long been used.

Harbison-Walker Refractories Co.,
Pittsburgh, Pa.

Movement for Increased Adoption of Metric System Gaining Headway

During the sixty-ninth meeting of the American Association for the Advancement of Science in New York during Christmas week, 1916, a conference was held, designated the "metric conference," at which were present representatives of national business organizations, the United States Department of Commerce and men prominent in engineering and educational work. The object of this conference was to discuss the Pan-American use of the metric system. Its outcome was the formation of a permanent organization to be known as the American Metric Association, to further the adoption of the international meter, gram and liter, which have been legalized in the United States since 1866.

The officers of the Association are as follows: President, George F. Kunz, 405 Fifth Avenue, New York; first vice-president, William Jay Schieffelin, 170 William Street, New York; second vice-president, E. P. Albrecht, The Bourse, Philadelphia, Pa., third vice-president, O. E. Stanley, Portland, Ore.; treasurer, Arthur P. Williams, 56 Hudson Street, New York; secretary, Howard Richards, Jr., 156 Fifth Avenue, New York. The executive committee consists of H. V. Army, 115 W. Sixty-eighth Street, New York; Fred R. Drake, Easton, Pa.; A. E. Kennelly, Massachusetts Institute of Technology, Cambridge, Mass.; S. W. Stratton, Bureau of Standards, Washington, D. C., and W. P. Wilson, Philadelphia Commercial Museum, Philadelphia, Pa.

The association now maintains an office at 156 Fifth Avenue, New York, and is especially desirous of receiving catalogs of manufacturers who use the metric system for domestic or export purposes.

The Processes of the Organic Chemical Industry Used in the Manufacture of Intermediate Products

III. Sulfonations and Caustic Fusions

By A. H. Ney and D. J. Van Marle

Sulfonations are the most common of all operations in the organic chemical industry and consist of the action of sulfuric acid on organic compounds, by which hydrogen is replaced by the sulfonic acid group, the products formed being called sulfonic acids.

The result of a sulfonation depends not only on the nature of the product sulfonated, but also on the amount and strength of the acid, the temperature during the sulfonation, and sometimes the time during which the mixture is heated.

The strength of acid used for sulfonation depends on the nature of the product to be sulfonated as there are products, such as benzol, phenol and naphthalene which are sulfonated very easily and therefore can be treated with ordinary concentrated sulfuric acid, and others, such as nitrobenzol, which only can be sulfonated with difficulty, for the sulfonation of which fuming sulfuric acid must be used. During the sulfonation water is formed, which dilutes the sulfuric acid in the mixture, and makes it necessary to use such an excess of acid that its concentration will not fall below the point, where it would become so dilute that it would no longer act on the material to be sulfonated.

The excess of acid required also depends on the temperature during the sulfonation, for, generally, the same results can be obtained with a larger amount of acid or with a stronger acid at a lower temperature as with a smaller amount of acid or a weaker one at a higher temperature. At the same time it must be taken into account that the temperature also has an influence on the position in which the sulfonic acid group enters the molecule and that a higher temperature sometimes causes more than one sulfonic acid group to enter, so that in every case it must be determined with what strength and amount of acid and at what temperature the best results can be obtained most economically. The heat developed is not so great as in nitrations and is mostly caused by the mixing of the acid and the water formed during the reaction. The temperature, at which sulfonations are carried out, is therefore, mostly higher than in nitrations, and cooling generally unnecessary.

In many instances, where different sulfonic acids are formed at different temperatures, the time also has a decided influence on the result of the sulfonation. Phenol, for example, is converted into a mixture of the ortho- and para-sulfonic acids at a low temperature, while at 100 deg. almost exclusively the para-sulfonic acid is formed, and it has been proven that the ortho-sulfonic acid at elevated temperature is transformed into the para-sulfonic acid. This is not an immediate conversion, but is due to the dilution of the acid, this more dilute acid having a reverse action, and splitting off the sulfonic acid group in ortho-position, which then enters the molecule again in the para-position. This phenomenon is especially of frequent occurrence in sulfonations in the naphthalene-series, the result of the sulfonation being an equilibrium between two or more sulfonic acids, the proportion of the different acids depending on the time of heating. Much better results can be obtained here, if the material is not added to the acid, but is fused and heated to the temperature at which the sulfonation has to be carried out, and the acid run in at constant temperature, whereby the equilibrium is reached in a much shorter time.

As to the position in which the sulfonic acid group

enters the molecule, the following rules can be laid down. In the benzene-series the same rule holds true as for nitrations, a sulfonic acid group entering in meta-position to another sulfonic acid group, a nitro-, carboxyl- or carbonyl-group already present. The sulfonic acid in these cases enters with some difficulty and a strong acid has to be used as well as a higher temperature.

If the product to be sulfonated contains chlorine-, alkyl-, hydroxyl- or amido groups, the sulfonic acid group enters into ortho and para position, their proportion depending on the conditions during the sulfonation, especially the temperature and the kind of acid used, the para-compound mostly being formed in much larger quantities than the ortho-compound.

The hydroxyl compounds are sulfonated most easily, resorcline for instance, being immediately converted into a disulfonic acid, the chlorine-compounds not so easily on account of the acid nature of the chlorine group.

The amido-compounds are in an exceptional position, in that they form acid sulfates with the acid, which neutralizes their basic properties, and causes, as in case of aniline and dimethylaniline, the sulfonic acid group to enter both in meta- and para-position. If, however, only sufficient acid is added to form the acid sulfate and this is heated to a temperature of 180-200 deg. the sulfonic acid group is forced exclusively in para position and a uniform product obtained with a minimum amount of acid.

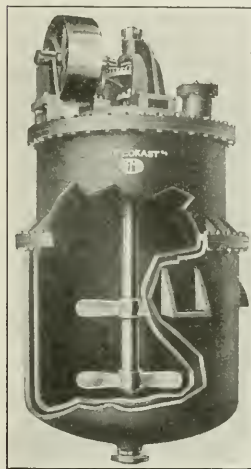


FIG. 1—SULFONATOR

This process, which is known as the baking-process, is used extensively in the manufacture of amido-sulfonic acids.

If two different groups are present before sulfonation, it will depend on their nature, where the sulfonic acid group enters, but if one of these groups is an amido-group its place will be determined by the other group.

In general, ortho-compounds are sulfonated easier than the corresponding para-compounds. Sulfonations in the benzene-series can be mostly carried out in such a way, that a uniform sulfonation product is obtained, which only has to be separated from the excess of sulfuric acid, which can be done by salting out the sulfonic acid or by neutralizing the mixture with lime and filtering off the precipitated gypsum, after which the lime salt is converted into the sodium salt by means of soda ash.

In the naphthalene-series there is a decided difference in the result of the sulfonations, as a mixture of two or more different sulfonic acids is formed. This is caused by the fact that the sulfonic acid group enters first in a position in which it is often not very strongly bound and, therefore, is partly split off again by hydrolysis, then entering in course of the sulfonation into another position.

The temperature and time of heating have a large influence here, at lower temperature, alpha-sulfonic acids, at high temperature beta-sulfonic acids being

formed, their rate of conversion into each other depending on the time.

As there are eight different positions, in which the sulfonic acid group can enter, the situation is very complicated. When naphthalene is sulfonated both the alpha- and beta-sulfonic acid is formed. On further sulfonation the sulfonic acid group enters by preference in the other ring and with hardly any exceptions it never places itself in ortho-, para- or peri-position to another sulfonic acid group.

Alpha nitro-naphthalene is converted into alpha-nitro-naphthalene 5 sulfonic acid, but as the sulfonation is not easy and the same product can be obtained in a different way, this way of preparation has not found any application.

If an amido- or hydroxyl-group is present, the result of the sulfonation will depend on the place of this group, the naphthols being sulfonated very easily, the naphthylamines with more difficulty. They will be discussed in detail later.

To chlorine in alpha-position the sulfonic acid group enters first in position 4, then in 5 and at higher temperature in positions 6 and 7. The manufacture of these chlorosulfonic acids is not of interest, with the possible exception of alpha-chloronaphthalene 4 sulfonic acid, which by caustic fusion can be converted into Neville-Winther acid, which could be done in practice where chlorine is available at a sufficiently low price.

As the result of the sulfonation is a mixture of different sulfonic acids, it will often be necessary in addition to a separation from the excess acid to carry out a separation of the sulfonic acids, which has to be done by means of the difference in solubility of their salts, by salting out these salts or by their difference in behavior toward diazo-compounds.

We will now discuss the influence of the acid and temperature more in detail.

Sulfuric Acid

Sulfuric acid of the different strengths which are used in the preparation of sulfonic acids, is available in the market. As we have seen, the acid will be diluted by the water formed during the reaction, and the amount for any sulfonation must be such that its concentration, after complete sulfonation, not taking into consideration the amount of sulfonic acid formed, will be high enough to have a sulfonating action on the material.

The sulfonating action of an acid depends in the first place on the degree, to which a product resists sulfonation. All products containing already a group of acid nature, viz., a nitro-, chlorine-, carboxyl- or carbonyl-group, can only be sulfonated with more or less difficulty, and the acid after sulfonation must, therefore, be of a higher concentration, than if the product is sulfonated easily, which is the case with the hydrocarbons and their hydroxyl-compounds.

The alkyl- and amido-compounds are in a medium position.

In the second place the sulfonating action depends on the degree of sulfonation desired, as the sulfonic acid group is of an acid nature and therefore, the molecule resists the entrance of a second and third sulfonic acid group more strongly, so that the concentration of the acid after sulfonation has to be raised accordingly.

It is obvious, that the stronger the acid is, we start with, the smaller will be the required amount, and that it is of advantage for all ordinary sulfonations to use 97-98 per cent sulfuric acid instead of the commercial 66 deg. B. acid, which has a strength of 92-93 per cent.

For instance, for the complete sulfonation of 100 lb. of benzol at 80 deg. C. 415 lb. 92 per cent sulfuric acid have to be taken, whereas, if the 98 per cent acid is

used only 265 lb. are required, in both cases, the concentration after sulfonation falling to 82 per cent, below which benzol is sulfonated only very slowly.

Not only a large amount of acid is saved, but as the excess of acid in the latter case is much smaller, less lime is required for neutralizing the mixture and a smaller bulk of gypsum has to be filtered off, which means in addition a saving in labor.

It would, therefore, be advantageous to use fuming sulfuric acid, of which a still smaller amount would be sufficient, but in the case under consideration this would result in the sulfonation being carried too far, as the first quantities of benzol not only would be mixed with a large excess of highly concentrated acid, but also much heat would be developed by the water liberated on mixing with the strong acid, both of which reasons would cause disulfonic acid to be formed.

To prevent this, it would be necessary to cool the mixture during the first part of the sulfonation, and heating it to the desired temperature after the acid has been sufficiently diluted by the water formed during the reaction, so that the danger of disulfonation has passed.

The foregoing tends to show that there is a lower as well as an upper limit to the concentration of the acid used.

Another way to overcome this difficulty is to start with an acid of ordinary concentration, run in the benzol, and then raise the strength of the acid by adding a sufficient amount of fuming sulfuric acid, as at this stage the dilution will be such as to prevent any disulfonation.

The most economical strength to use will depend in every case on the current price of the available acids. To convert the benzene-sulfonic acid into the disulfonic acid, fuming sulfuric acid containing 20-25 per cent free SO_3 is required, while at the same time the sulfonation has to be carried out at a higher temperature.

To make the trisulfonic acid a larger amount of this acid has to be used and again it would be of advantage to take a stronger acid, were it not that fuming sulfuric acid, containing 30-55 per cent SO_3 , is solid at ordinary temperatures and troublesome to handle. Acids with 55-70 per cent free SO_3 are, however, liquid, and these could be used for reinforcement of the acid, after the sulfonation has been partly completed.

Benzene-trisulfonic acid cannot be sulfonated any further as the sulfonic acid group cannot enter in meta-position to those already present. It is not used for any purpose, as are the naphthalene-trisulfonic acids, which at very high temperature can even be sulfonated to a tetra-sulfonic acid.

Fuming sulfuric acid is also used for those compounds in which the sulfonic acid group enters only with difficulty, such as nitrobenzol, benzoic acid, and amidophenols and for those that have to be sulfonated at low temperatures such as dimethylaniline and many dyes, as the same result can be obtained with a stronger acid at lower temperature as with a weaker acid at higher temperature, providing the temperature has no influence on the nature of the sulfonic acid formed.

In certain cases another point of importance, with regard to the strength of the acid used, has to be taken into consideration, namely, the fact already mentioned, that often the sulfonic acid group enters in a position in which it is not very stable. For instance, in phenol ortho-sulfonic acid, meta-xytol sulfonic acid and meta-cresol sulfonic acid the sulfonic acid group is split off even by boiling with dilute acids, which fact in the last of the three cited cases has found application for the separation of meta and para-cresol. Their mixture is sulfonated, and after diluting the meta-cresol sulfonic acid decomposed by boiling, whereupon the meta-cresol

can be distilled off with steam, the para-cresol sulfonic acid remaining in solution.

This hydrolytic action of the acid also has its influence in the naphthalene-series, where in a number of instances the sulfonic acid group is split off in the position, where it enters first, and afterwards places itself in a more stable position, which is one of the reasons, that in this series, mixtures of different sulfonic acids are formed, the time of heating here having a decided influence on the composition of the mixture. It may, therefore, be necessary to change the strength of acid according to the result desired.

Sulfonations also can be carried out by means of chlorosulfonic acid, which is obtained from sulfur-trioxide and hydrochloric acid gas, or by passing this gas through fuming sulfuric acid and distilling the product. If not used in excess, sulfonic acids are formed and hydrochloric acid liberated, which latter substance, however, introduces serious mechanical difficulties. If used in excess, sulfo-chlorides are formed, the hydroxyl group of the sulfonic acid being replaced by chlorine.

In addition it has the property to direct the sulfonic acid group to a different position than sulfuric acid would and it is in these cases, where a different product can be obtained, that it has found application. Toluol, for instance, by ordinary sulfonation is converted for the greater part into paratoluol sulfonic acid, whereas by the action of chlor-sulfonic acid below 5° C. 60 per cent of the ortho-chlor-sulfonic acid is formed, and which has found a large application in the manufacture of saccharine. In the sulfonation of betanaphthol first the betanaphthol ortho-sulfonic acid is formed which has the sulfonic acid group in position 1, and which under ordinary conditions is immediately transformed into other acids. By dissolving the beta-naphthol in carbon disulfide and submitting it to the action of chlor-sulfonic acid this product, however, can be prepared.

It has been suggested to replace fuming sulfuric acid by a mixture of sulfuric acid and pyrosulfate, but as this introduces a large amount of sodium bisulfate in the sulfonation-mixture, it is not done to any great extent.

There is a class of sulfonations, to which here properly may be called attention, those by means of sodium bisulfite. Amido-compounds form sulfurous ethers with sodium bisulfite, which under certain conditions can be converted into sulfaminic acids and further into amido-sulfonic acids, the sulfonic acid group placing itself in para-position to the amido group, or occasionally in ortho-position. In practice, the starting point for these sulfonations are nitro- or nitroso-compounds, which first are reduced by the bisulfite to hydroxylamine compounds, which also are able to form sulfaminic acids. This reaction has enabled the manufacture of an important intermediate, 1-2 amido naphthol 4 sulfonic acid from beta-naphthol the latter being first converted into nitrosonaphthol.

Temperature and Time

As already stated, the temperature during the sulfonation is of the utmost importance, not only that the nature of the sulfonic acid depends on it, but also, that it influences the result of the sulfonation in connection with the amount and concentration of the acid. If a product is sulfonated without difficulty, there is danger that more than one sulfonic acid group enters the molecule and the higher the temperature is, the greater this danger, as the action of the acid will be stronger at more elevated temperature, which may make it necessary to cool the mixture, especially in the beginning of the operation, while in many other cases heating is required

to complete the sulfonation. On the other hand, the acid at a higher temperature may decompose part of the product and cause a loss of material. The temperature, therefore, varies according to conditions, ranging all the way from 0 deg. to 200 deg. C.

Since it is most economical to use as concentrated an acid as possible, unless it has an influence on the nature of the sulfonation product the temperature will not be a deciding factor, and will be determined by the strength of acid. In order not to use an excessive amount of acid, the temperature is raised at the end of the operation sufficiently high to complete the sulfonation, time also being saved in this way and the capacity of the apparatus increased correspondingly. In cases where the acid has a corrosive action on the substance sulfonated at higher temperatures, which would impair the quality or the yield of the product, as for example in the sulfonation of beta-naphthol and many dyes, the amount and strength of the acid has to be chosen in accordance with the maximum temperature to which the mixture can be heated.

The heat developed by the reaction itself is not great, so that there is little danger of losing control over the operations as in case of nitrations and reductions, the only result here being that the sulfonation will be carried too far and the material may be partly decomposed.

In the benzene-series, the temperature has little influence on the nature of the product obtained, with the exception of the phenol-sulfonic acids, where the para-compound is almost exclusively formed at higher temperature and in the sulfonation of benzol. Benzene-sulfonic acid is converted up to 90 per cent into the meta-disulfonic acid, the amount of the para-compound which is formed as a by-product, increasing at higher temperature and on longer heating.

It is in the naphthalene-series, that the result of the sulfonation depends entirely on the temperature, the amount and concentration of the acid simply determining the degree of sulfonation.

When naphthalene is sulfonated, a mixture of alpha- and beta-sulfonic acid is formed, and it is not possible to obtain one of these acids exclusively for the reasons mentioned before. At 80 deg. about 80 per cent of the alpha-sulfonic acid is obtained, while at 160 deg. about 85 per cent of the beta-sulfonic acid is formed, the equilibrium gradually changing from one to the other at intermediate temperatures. The old way of preparing the beta-sulfonic acid was to heat the acid to 120-130 deg., add the naphthalene, heat the mixture at 160 deg. for a sufficiently long time to convert the alpha-sulfonic acid into the beta-sulfonic acid and then raise the temperature to 175-180 deg. to drive out the water and complete the sulfonation, which allowed a material saving to be made in the amount of acid required. On the other hand this high temperature caused a small amount of the sulfonic acid to be converted into sultone, while part of the naphthalene escaped sulfonation, as it evaporated with the water.

It is therefore, a great advantage to follow the process, described by Witt, which consists in fusing the naphthalene, heating it to 160 deg. and running in the acid slowly, keeping the temperature throughout at 160 deg. The amount of acid required is larger, as the water is not driven off, but no sultone is formed and no naphthalene escapes sulfonation, so that a higher yield is obtained of a product of better quality.

Another great advantage over the old process is, that the sulfonation is carried out at a uniform temperature of 160 deg. C., so that the maximum amount of beta-sulfonic acid is formed immediately, and no time has to be wasted for converting the alpha-sulfonic acid into the beta-sulfonic acid. It is this feature of the process

which makes it profitable to apply it also in the manufacture of the higher sulfonic acids of naphthalene.

On further sulfonation of alpha-naphthalene-sulfonic acid at lower temperature, the sulfonic acid group enters again in alpha-position, but in the other ring and as position 8 is protected, we will obtain the 1-5 disulfonic acid. In this acid the two remaining alpha-positions are in para-position to those already occupied, so that a third and fourth sulfonic acid group will have to enter in beta-position, of which position 2 and 6 again are protected, being in ortho-position to those taken up. We, therefore, obtain the 1-3-5 naphthalene-trisulfonic acid and 1-3-5-7 tetrasulfonic acid.

If alpha-naphthalene sulfonic acid is sulfonated at a little higher temperature, the sulfonic acid group also will place itself in beta-position, and 1-6 disulfonic acid being obtained, which can further be converted into the 1-3-6 trisulfonic acid and the 1-3-6-8 tetrasulfonic acid.

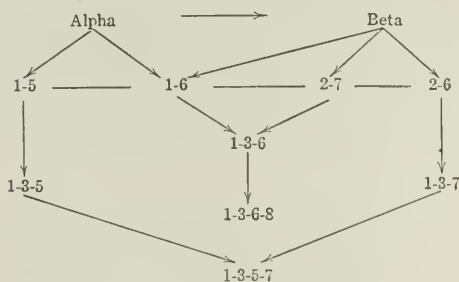
These last two are the only ones that can be formed, and we, therefore, would obtain a uniform sulfonation product if it was not that the 1-6 disulfonic acid will always be contaminated with the 1-5 disulfonic acid, which is formed at the same time and with the disulfonic acid, obtained from the small amount of beta-sulfonic acid, present in the alpha-acid.

To purify the 1-6 disulfonic acid first would be tedious and it is generally preferred to postpone any purification until the ultimate product has been prepared.

In the beta-sulfonic acid the sulfonic acid at lower temperature can enter into alpha-position, which will give us the 1-6 disulfonic acid, at higher temperature into the beta position, when we will get a mixture of the 2-6 and 2-7 disulfonic acids.

All these disulfonic acids are convertible into each other, the 2-6 acid being the most stable at the highest temperature. Both the 1-6 and 2-7 disulfonic acids can be converted into the 1-3-6 trisulfonic acid and the 1-3-6-8 tetrasulfonic acid, while the 2-6 disulfonic acid forms the 1-3-7 trisulfonic acid, which like the 1-3-5 trisulfonic acid goes over into the 1-3-5-7 tetrasulfonic acid. In case of the 2-6 and 2-7 disulfonic acids, the two remaining beta-positions are protected and another sulfonic acid group, therefore, has to enter in alpha-position, even at higher temperature. In the 1-3-6-8 tetrasulfonic acid we have an exception to the rules, in that the sulfonic acid group places itself in position 8, or in peri-position to another sulfonic acid group.

The preceding can be readily followed with the aid of the diagram below:



As pointed out Witt's process here also will give more favorable results, as, for instance, the beta-sulfonic acid can first be prepared, and converted at 160 deg. into the disulfonic acid by an additional amount of acid, the maximum amount of 2-7 disulfonic acid then being obtained, which subsequently can be converted into the 1-3-6 trisulfonic acid by reinforcing the acid.

The naphthols are sulfonated very easily, and care has to be taken that the temperature is not carried above

the point where the corrosive action of the acid will become noticeable.

Sulfonation of alpha-naphthol yields a mixture of the 2 and 4 sulfonic acids, and the 2-4 disulfonic acid, while at a little higher temperature the 2-4-7 trisulfonic acid is formed with a small amount of 2-4-6 trisulfonic acid. The sulfonic acid groups in positions 2 and 4 are not very strongly bound, which causes the 2-7 and 4-7 disulfonic acids also to appear in the sulfonation-mixture. If the hydroxyl-group is protected, however, which can be done by converting the alpha-naphthol into alpha-naphthol carbonate the sulfonation will go much more smoothly, first the 4 sulfonic acid being obtained, then a mixture of the 4-6 and 4-7 disulfonic acids, in analogy to the sulfonation of alpha-naphthylamine. It appears that the sulfonic acid group in alpha-naphthol derivatives never enters in position 3, 5 or 8.

In beta-naphthol the sulfonic acid group first enters in position 1, in which it is so unstable that it is immediately converted into the 8 sulfonic acid or Croceine acid which in its turn at higher temperature goes over into the 6 sulfonic acid or Schaeffer acid. On further sulfonation these two acids form the 6-8 disulfonic acid or G-acid, and the 3-6 disulfonic acid or R-acid respectively, both of which are generally prepared by direct sulfonation of beta-naphthol at different temperatures and both of which ultimately go over into the 3-6-8 trisulfonic acid. The beta-naphthol 7 sulfonic acid can be sulfonated to a mixture of the 1-7 and 3-7 disulfonic acids, which can be converted into the 1-3-7 trisulfonic acid and ultimately into the 1-3-6-7 tetrasulfonic acid, which is the only case in which the sulfonic acid group enters into orthoposition to another one.

Alpha-naphthylamine is converted into a mixture of the 4 and 5 sulfonic acids, the latter being obtained in greater amount with fuming sulfuric acid at a low temperature, and the former most at higher temperature, while at the same time a small amount of the 6 sulfonic acid is formed. The 4 sulfonic acid or naphthionic acid, which is the most important, is made preferably according to the baking-process. By further sulfonation it goes over into a mixture of the 4-6 and 4-7 disulfonic acids, generally known as Dahl's acids II and III, the 5 sulfonic acid into a mixture of the 2-5 and 5-7 sulfonic acids, both of which can be converted into the 2-5-7 trisulfonic acid.

In the other alpha-naphthylamine sulfonic acids, which can mostly be obtained by nitration and reduction of the naphthalene-sulfonic acids, a second sulfonic acid group enters in position 4 or 5, a third one in position 2 or 7, as can be seen from the following table:

Sulf. Acid	Disulf. Acid	Trisulf. Acid
2	2-5	2-5-7
3	3-5	3-5-7
6	4-6	2-4-6
7	4-7	2-4-7
8	4-8	2-4-8

The alpha-naphthylamine 5-7 disulfonic acid, which is of technical importance can be prepared by sulfonation of alpha-acet-naphthalide, the acetyl-group protecting position 2 and 4, which causes the sulfonic acid group to enter exclusively in position 5, the 5 sulfonic acid then being converted into the 5-7 disulfonic acid only.

The sulfonation of beta-naphthylamine is very complicated, a mixture of the 5, 6, 7 and 8 sulfonic acids being formed, the 5 and 8 sulfonic acid to a greater degree at lower temperature, being alpha-sulphonic acids, the others at higher temperature. It is hardly possi-

ble to prepare them in a pure state, except the 5 sulfonic acid, which can be obtained by sulfonation of beta-acetnaphthalide. The others are preferably made by replacing the hydroxyl-group by the amido-group in beta-naphthol sulfonic acids by means of ammonia. A second sulfonic acid group enters often in position, in which position, however, it is not stable, and may also enter in the same ring in meta position to the first one.

Caustic Fusions

Closely connected with the sulfonations are the caustic fusions, which convert the sulfonic acids into hydroxyl-compounds by fusing them with caustic soda. The sulfonic acid, probably under influence of the caustic soda, first goes over into an ester of sulfurous acid, which subsequently is decomposed into a phenolic body and sodium sulfite. This reaction takes place only at a high temperature, which makes it necessary to use an excess of caustic soda to keep the mixture in a liquid state at this temperature, but as many organic compounds are easily oxidized in the presence of caustic soda at a high temperature, especially if there are any amido-groups present in the molecule, a considerable amount of material is lost through oxidation and the yield leaves much to be desired. This can often be improved by carrying out the caustic fusion with water

these higher sulfonic acids the sulfonic acid groups are not all at once replaced, benzene meta-disulfonic acid, for instance, first being converted into phenol meta-sulfonic acid, then into meta-dioxybenzol or resorcin. A peculiarity of the caustic fusions is that sometimes the hydroxyl-group not always enters in the same position as the sulfonic acid, which it replaces, which can be illustrated by the fact that benzene-ortho- and para-disulfonic acid by fusion with caustic soda also are converted into resorcin.

In the naphthalene-series the sulfonic acid groups in alpha-position are, as a rule, easier replaced by the hydroxyl-group than those in beta-position, which has made the manufacture of amido-naphthol sulfonic acids from naphthylamine sulfonic acids possible. Especially those of 1-8 amido-naphthol such as H-acid and 2-8 amido-naphthol, such as Gamma acid, are of great practical importance. The replacement of a sulfonic acid group in alpha-position is especially easy, if it is in position 8 to an amido-group or in meta-position to another sulfonic acid group. If these fusions of naphthylamine-sulfonic acid are carried out in the presence of water it must be taken into consideration that the amido-group also may be replaced by the hydroxyl-group, due to the hydrolytic action of the water, which may cause the 1-8 amido-naphthol 3-6 disulfonic acid or H-acid, for example, to be converted into 1-8 dioxy-naphthalene 3-6 disulfonic acid or chromotropic acid. A few of the naphthalene sulfonic acids also are converted into naphthol-sulfonic acids by caustic fusion.

Of the fact, that the material can be oxidized in the presence of caustic soda advantage has been taken in the manufacture of alizarine and other anthracene dyes. Alizarine is made by sulfonation of anthraquinone and caustic fusion of the sulfonic acid, the mono-sulfonic acid hereby being converted into dioxy-anthraquinone or alizarine. Usually the oxygen needed for the oxidation is not supplied by the air alone, but partly by an oxidizing agent, such as sodium chlorate or sodium nitrate.

Not only the sulfonic acid group but also the chlorine-group under certain conditions can be replaced by the hydroxyl-group. If this could be done in chlorbenzol we would have a very simple process for the manufacture of carboic acid, but the temperature at which the chlorine-group here is replaced is so high that the resulting pressure is too high to make the process of commercial interest. If any acid groups are present in the molecule, however, the conversion becomes easier and can be carried out under workable conditions. So, for instance, in ortho- and para-nitrochlorbenzol, the chlorine is made removable by the presence of the nitro-group, making it possible to convert them into ortho- and para-nitrophenol. If two nitro-groups are present, as in dinitrochlorbenzol, the conversion is so easy that boiling with caustic soda is already sufficient to form dinitrophenol. In the naphthalene-series we find an example in alpha-chloronaphthalene 4 sulfonic acid, from which alpha-naphthol 4 sulfonic acid, an important intermediate, may be prepared.

That the sulfonic acid group is not always replaced, we can see in the case of naphthionic acid, which by the action of concentrated caustic soda solution under pressure, can be converted into alpha-naphthol 4 sulfonic acid, the amido-group being replaced instead of the sulfonic acid group. The conversion is not easy, however, and the process has been practically abandoned.

To obtain the hydroxyl-compounds in a pure state, the fusion mixture is dissolved in water and the solution acidulated, the acidulation being carried only so

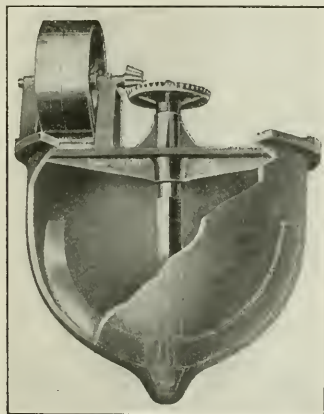


FIG. 2—FUSION KETTLE

in autoclaves under pressure, which allows the amount of caustic soda to be cut down materially and prevents oxidation. The disadvantages of using autoclaves is their limited capacity and the long time required for their operation, wherefore they are used only in such cases where the materials are more expensive or the amount of caustic soda required for fusion in open kettles is excessive.

In the manufacture of carboic acid from benzene-sulfonic acid and beta-naphthol from beta-naphthalene sulfonic acid, which are both manufactured in very large quantities, the use of autoclaves, therefore, is not practicable. These two products, being mono-sulfonic acids the excess of caustic soda required is not large, it having also been found in the case of carboic acid that pressure-fusion has no favorable influence on the yield. In the case of di- and trisulfonic acids, however, a much larger excess of caustic soda has to be used, and here generally the use of autoclaves will be preferred. These products at the same time are the more expensive ones, and mostly not prepared in such large amounts. In

far that the sulfite is converted into bisulfite. If the hydroxyl-compound is soluble, as is often the case, it can then be precipitated by addition of salt to the solution. Resorcline forms an exception, in that it is soluble in water and cannot be salted out. To obtain it in a pure form, the solution is extracted with an organic solvent and the crude resorcline distilled in vacuum.

Application

The sulfonic acids of benzol are only manufactured as intermediate products in the production of phenol and resorcline, into which the mono- and disulfonic acid respectively are converted by caustic fusion. The first is only used to a small extent in the preparation of dyes, but in enormous quantities as an antiseptic and in the manufacture of artificial resins and picric acid. Its production during the year 1916 was estimated at 10,000 tons. Nitroso-phenol, which enters in the manufacture of a few dyes, can be made from phenol by the action of sodium nitrite. Salicylic acid, which also can be made from phenol, has found application both in the dyestuff industry and for medicinal purposes, as has resorcline. To make picric acid from phenol it is necessary to sulfonate the phenol first, and it is possible to make it from either the mono-sulfonic acid or the trisulfonic acid. The first is treated with a large excess of nitric acid and does not give a very good yield, while the second, which has to be made with fuming sulfuric acid and, therefore, is more expensive, can be converted into picric acid with only a slight excess of nitric acid or its equivalent in sodium nitrate and gives a better yield.

Ortho-toluol sulfochloride, which is formed by the action of chlorsulfonic acid on toluol, is the starting point in the manufacture of saccharine. The para-compound is obtained as a by-product and has found application in the form of its methyl- or ethyl-ester as an excellent alkylating agent.

The sulfonic acid of nitrobenzol is converted by reduction into metanilic acid, which is mainly used in the manufacture of metanil yellow. The metanilic acid by caustic fusion gives meta-amidophenol, one of the intermediate products in the preparation of the Rhodamine dyes. The alkyl compounds of meta-amido phenol, which also are used for this purpose, are obtained by sulfonation of the alkyl-compounds of aniline with fuming sulfuric acid at low temperature, followed by caustic fusion.

Para-nitrotoluol sulfonic acid is the basic material for the manufacture of the stilbene-dyes, chrysophenine and brilliant-yellow. Of other nitro-sulfonic acids those of nitrochlorbenzol deserve attention. The chlorine-group here is unstable and can be replaced by the hydroxyl-group by means of caustic soda. On reduction, we then can obtain the amidophenol sulfonic acids, the ortho-amidophenol sulfonic acid giving important chrome-dyes of excellent fastness. In nitrochlorbenzol itself, the chlorine-group can also be replaced by the hydroxyl-group, as we have seen. Of the nitrophenols formed, the para compound can be used for manufacturing para-amidophenol, the ortho compound for anisidine and dianisidine. The nitrochlorbenzol-sulfonic acids can also be converted into nitraniline-sulfonic acids, from which a few lake-dyes are derived.

The sulfonic acids of amido-compounds, such as aniline, toluidine, xyldine, amidoazobenzol, meta-phenylene diamine and meta-tolylene diamine are intermediate products for the manufacture of many azo dyes. Ethyl-benzylaniline sulfonic acid is more used for triphenylmethane-dyes.

Naphthalene-sulfonic acids are only intermediate products in the manufacture of other naphthalene-compounds. By caustic fusion they can be converted

into naphthols and naphthol sulfonic acids. The most important one is the beta-naphthalene sulfonic acid, the first stage in the preparation of beta-naphthol, which is used in enormous quantities for making beta-naphthylamine, beta-naphthol sulfonic acids, para red and many other dyes. Alpha-naphthol generally is not made from alpha-naphthalene sulfonic acid, but from alpha-naphthylamine sulfate by heating this with water under pressure. Its application is limited, as we have seen that on sulfonation an inseparable mixture of sulfonic acids is formed. This mixture on nitration can be converted into naphthol yellow, the most important dye made from alpha-naphthol. Other naphthol-sulfonic acids, obtained from naphthalene-sulfonic acids, are Cleve's alpha-naphthol 5 sulfonic acid, alpha-naphthol 3-6 sulfonic acid GR and beta-naphthol 7 sulfonic acid F. The first two are used for azo-dyes, the last one for preparing a blue shade of para-red and for making beta-naphthylamine 7 sulfonic acid.

By nitration, followed by reduction, the naphthalene-sulfonic acids can be converted into alpha-naphthylamine sulfonic acids. The most important are alpha naphthylamine 8 sulfonic acid from the alpha-sulfonic acid, the 5 sulfonic acid or Laurent acid being obtained as a by-product; a mixture of Cleve's alpha-naphthylamine 6 and 7 sulfonic acid from the beta-sulfonic acid and Freund's alpha-naphthylamine 3-6 disulfonic acid from the 2-7 disulfonic acid, all of which are used in the manufacture of azo-dyes. Others are not used as such, but only for the preparation of other intermediate products. The amido-group, for instance, can by different means be replaced by the hydroxyl-group, thereby forming alpha-naphthol sulfonic acids, which is done for the preparation of alpha-naphthol 3-8, and 4-8 disulfonic acids and the 3-6-8 trisulfonic acid.

Of the alpha-naphthylamine sulfonic acids, obtainable by direct sulfonation, naphthionic acid is the most important, and used in large quantities for preparing azo-dyes and in the manufacture of Neville Winther's alpha naphthol 4 sulfonic acid. Laurent's alpha-naphthylamine 5 sulfonic acid is not made by direct sulfonation, as it then is not pure, and it is obtained in sufficient quantities as a by-product in the manufacture of the 8 sulfonic acid.

The beta-naphthylamine sulfonic acids, as already mentioned, can only be prepared in a pure state from the beta-naphthol sulfonic acids by means of ammonia. All naphthylamine di and trisulfonic acids can be converted into amidonaphthol sulfonic acids by caustic fusion. The most important is H acid or 1-8 amido-naphthol 3-6 sulfonic acid, obtained by nitration and reduction of naphthalene 1-3-6 trisulfonic acid followed by caustic fusion. Gamma acid or 2-8 amido-naphthol 6 sulfonic acid is next in importance and can be prepared by converting beta-naphthol 6-8 disulfonic acid G into the corresponding beta-naphthylamine compound and fusing this with caustic soda. Others are 1-8 amido-naphthol 4 sulfonic acid S, 2-4 disulfonic acid S, and 4-6 disulfonic acid K, 1-5 amido-naphthol 7 sulfonic acid M, 2-7 amido-naphthol 7 sulfonic acid J, and 2-8 amido-naphthol 3-6 disulfonic acid RR, which all are made from the corresponding naphthylamine sulfonic acids. The 1-2 amido-naphthol 4 sulfonic acid is prepared from nitroso beta-naphthol with sodium sulfite, and the amido and hydroxyl group being in ortho position to each other, it gives valuable chrome dyes.

The beta-naphthol sulfonic acids, which have been mentioned, also are of great importance. We obtain a mixture of the Croceine and Schaeffer acid or of the R and G acid, of which the Croceine and G acid and their salts are much more soluble than the other two, of which property we can make use for their separation, in that the salts of Schaeffer and R acid can be pre-

precipitated by adding salt to their solutions. The precipitate can be washed with salt-solution free of the other component acid which separation is quite satisfactory for preparing Schaeffer and R salt. The precipitation, however, is not complete and the other two acids can, therefore, not be purified in this way. As they both contain a sulfonic acid group in position 8, they combine much slower with certain diazo-compounds, especially diazo-xytol, than Schaeffer and R salt. Their purification is carried out by combining these two acids with diazo-xytol or another suitable diazo-compound and salting out the dye found, the pure Croceine or G salt remaining in the mother-liquor, from which they can be obtained by evaporation.

Further sulfonic acids of the naphthalene-series are 1-8 dioxy-naphthalene 3-6 disulfonic acid or chromotropic acid, obtained by replacing two sulfonic acid groups in 1-3-6-8 naphthalene tetra sulfonic acid with caustic soda; or by fusing alpha-naphthol 3-6-8 trisulfonic acid with caustic soda; 1-8 dioxy-naphthalene 4 sulfonic acid, made by replacing the amido by the hydroxyl-group in 1-8 amido-naphthol 4 sulfonic acid, and the sulfonic acids of dioxy-naphthoic acid. These are prepared by converting alpha- or beta-naphthol into the oxy-naphthoic acid in the same way as salicylic acid is made from phenol, sulfonating this product and fusing the disulfonic acid with caustic soda.

All these sulfonic acids of the naphthalene-series are almost exclusively used in the manufacture of azo-dyes.

Sulfonations and caustic fusions are also carried out to a large extent in the manufacture of many anthracene-dyes, the simplest of which is alizarine, made by sulfonation of anthraquinone and caustic fusion of the sulfonic acid in the presence of an oxydizing agent, whereby dioxyanthraquinone is formed, which is alizarine, the well-known substitute for Madder.

Dyes are often sulfonated to increase their solubility or improve their quality otherwise. The best known examples are alkali blue, soluble blue, water blue, patent blue, primuline, induline and nigrosine.

Apparatus

Sulfonations are carried out in kettles of acid-proof cast iron, provided with an agitator. With the exception of benzol and toluol, all materials to be sulfonated in the ordinary way are solids and as the sulfonic acids are all soluble in the excess acid the sulfonation mixture is homogeneous, so that a simple agitator of the propeller or horseshoe type will be sufficient. In the case of benzol, however, the agitation has to be very thorough, as benzol is immiscible with and very much lighter than sulfuric acid. The best type of agitator is a high speed propeller placed inside a cylinder, which is perforated at the bottom. The propeller is run in such a direction that it takes the benzol down from the surface, mixes it with the acid and forces the mixture through the openings at the bottom and causes it to rise along the sides of the kettle. In general, sulfonations are very simple, and can be carried out without difficulty, the acid being run into the kettle, the material being added gradually and the mixture being kept at the desired temperature until the sulfonation has been completed.

As we have seen, sometimes the mixture is cooled during the first part of the operation and heated afterward, generally by means of steam, which can be easily done by providing the sulfonating kettle with a jacket. If steam-pressure is not sufficient to reach the desired temperature, the heating can be done by means of an oil-bath, which is heated directly. Wherever a battery of kettles has to be heated, it is more economical to circulate oil through the jackets of the kettles and have a

central heating system. If a sulfonation at high temperature is followed by a nitration, the sulfonating kettle has to be oil-heated and the mixture has to be transferred to a second kettle, in which it can be cooled and nitrated. It would be of advantage to carry the operation through in one kettle, which can be done if the kettle has a heating-coil cast in, through which first pressure-water is circulated which, after the sulfonation is complete, is gradually replaced by cold water.

The sulfonation of amido-compounds is often carried out, as already mentioned, by heating the acid sulfate at a temperature of about 200 deg., which is done in an oven in which this acid sulfate is placed in trays on shelves, which are heated by means of furnace-gases. The operation can be considerably facilitated by conducting the operation in a vacuum.

The separation of the excess sulfuric acid from the sulfonic acid can be done in three different ways. If the sulfonic acid is not soluble in dilute acid, as in case of beta-naphthalene sulfonic acid the sulfonation mixture can be diluted with water, which causes the sulfonic acid to precipitate. If a large excess of sulfuric acid is used, the sulfonic acid can often be precipitated by adding salt to the diluted sulfonation mixture, which sometimes effects a separation of sulf. acids of different solubility at the same time. In both cases large amounts of dilute acid have to be handled and acid-proof filtering devices, which are yet far from perfect, have to be used. If the sulfonic acid, and its salts, however, are too soluble under these conditions, or if it is preferred not to handle any acid liquors, the sulfonation mixture can be neutralized with lime, the sulfuric acid being precipitated as gypsum, which can be filtered off in ordinary filterpresses and washed. The sulfonic acid then is obtained in form of its lime salt, which is converted into the sodium salt by means of soda ash, as the lime salts generally cannot be used as such. If a caustic fusion follows the sulfonation, the lime would cause the fusion-mixture to become very thick, and a large excess of caustic soda would be required. Many sulfonic acids are used directly in the manufacture of dyes, especially azo-dyes, and here the lime might often cause the dye to precipitate as a lime salt, insoluble in water.

The sodium salts of the sulfonic acids are soluble in water, which solution sometimes can be used immediately in the manufacture of dyes. If a mixture of sulfonic acids is formed, it may be desirable to separate them, before they are used further, which can often be effected by salting out the sodium salt or the acid sodium salt of the least soluble sulfonic acid. For all

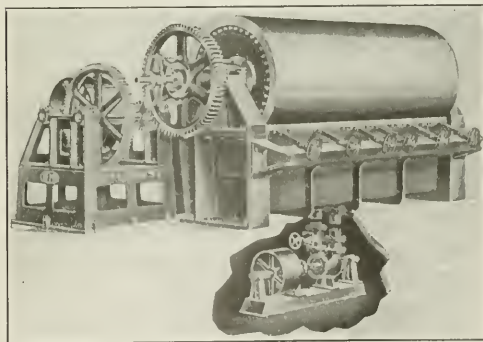


FIG. 3—ATMOSPHERIC DRUM DRYER

these operations, following a sulfonation, only wooden or lead-lined tanks and filtering apparatus are required.

In the manufacture of carbolic acid the sodium sulfonate of benzol is obtained in solution, which must be evaporated to dryness. As enormous amounts of this product are produced at the same time, it is important to do this in the most economical way, which consists in concentrating the solution in a vacuum-evaporator and evaporating the concentrated solution to dryness in one operation on an atmospheric drum dryer, thereby bringing down the cost of this operation to a minimum. This apparatus can be used to advantage in all similar cases wherever the sodium salt of a sulfonic acid has to be prepared in the dry state.

Caustic fusions are carried out either in open cast iron kettles, in which the caustic soda is fused and the sodium sulfonate gradually added or in autoclaves under pressure. For pressures up to 500 lb. these autoclaves can be made of cast iron, but for higher pressures they have to be made of cast steel. Both autoclaves and fusion kettles are provided with an agitator and are placed in a furnace, which is heated by oil or gas, as the temperature to which the mixture is heated is often above 300 deg. C. When the fusion is finished the mixture is dissolved in water. The contents of an autoclave are sufficiently liquid to blow them into water by air-pressure, but in case open kettles are used the mixture is generally ladled out, allowed to solidify and then dissolved. It has been tried to provide these fusion kettles with a bottom-outlet, in order to run out the mixture, but as it is difficult to keep these bottom openings tightly closed and as they burn out gradually, they have not given much satisfaction. The operations following a caustic fusion, consisting in acidulating the solution of the fusion mixture, separating out the hydroxyl-compound if necessary, and filtering this off, requires only wooden tanks and simple filtering devices. Carbolic acid separates out as a liquid, and the acidulation is, therefore, carried out in iron tanks with conical bottom. The soluble hydroxyl compounds can be purified by recrystallization. Phenol, alpha- and betanaphthol are purified by distillation, the latter two in vacuum.

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Synopsis of Recent Metallurgical and Chemical Literature

Refrigeration

The Steam Jet Refrigerating Machine.—In the *Electric Journal* for January, J. C. BERTSCH of the Westinghouse Machine Co., describes the Leblanc refrigerating machine which produces refrigeration by the evaporation of water. The process is an old one, strictly speaking, but its successful commercial development is comparatively recent. To Maurice Leblanc, of France, is given the credit for perfecting this machine, and developing the high vacuum-producing and vapor displacing devices known as the Westinghouse-Leblanc ejector and air pump. With the use of these appliances, the refrigerating process consists simply of the evaporation of a part of the water contained in the substance to be cooled or concentrated under a very high vacuum, which is produced by steam jets; the condensation of the vapor and working steam and the removal of the air and condensate from the condenser by special pumps.

A diagram of the apparatus as used for general purposes is shown in Fig. 1. For temperatures above 35 deg. F., as required for air conditioning plants, drinking water systems, rubber rolls, etc., water alone

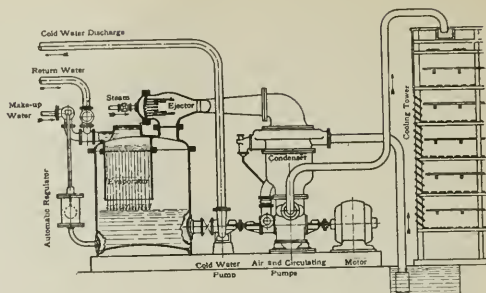


FIG. 1—TYPICAL ARRANGEMENT OF LEBLANC REFRIGERATING MACHINE

is used as the cold carrier, but for temperatures below 35 deg. F., salt brine is used as carrier.

The evaporator is divided by a cylindrical partition into a brine and vapor space, the former has near the top a perforated horizontal partition as shown, through which the warm brine from the cooling coils is returned to the evaporator in the form of a spray. The make up regulator, consisting of a float valve, controls automatically the amount of makeup water needed to replenish the water lost by evaporation.

The evaporation under vacuum and subsequent cooling is produced by the steam ejector shown at the top of the vapor space. This is the most important part of the apparatus, as it maintains a high vacuum and removes the great quantities of vapor necessary. It is made up a large number of small De Laval steam nozzles, which give a high velocity. The condenser is a steam condenser as commonly used in connection with turbines and steam engines. A cooling tower is very desirable. A specially designed Leblanc air pump is used for removing the air in the condensed water. For the circulation of the cold brine a cold water pump (centrifugal type) is used as shown. The entire absence of chemicals, the automatic operation, and the limitation of the moving parts to a few centrifugal pumps, make very little attention necessary. Actual tests on a 60-ton machine in a rubber plant showed a cost per ton of refrigeration of \$0.304 to \$0.334, producing 72-79 tons per day. Besides chemical and sugar works, the machine is specially suited for marine works.

Iron and Steel

Grain-growth in Low Carbon Steel.—At the eighty-first meeting of the Faraday Society on Dec. 18, 1916, in London, a paper on "Grain-growth in Deformed and Annealed Low Carbon Steel," presented by RALPH H. SHERRY of Detroit, U. S. A., was read by Sir Robert Hadfield for the author.

Coarse crystallization or grain-growth in pure iron and low-carbon steels permanently deformed and annealed has from time to time caused no little difficulty to workers in sheet, wire, cold-drawn bar and pressings of these materials. The present paper, based on an extended investigation, explains the conditions under which grain-growth occurs.

The author summarizes his results as follows:

1. Grain-growth in low-carbon steel will be produced by permanent deformation of the metal within certain limits, followed by annealing within certain temperature ranges.
2. The greater the amount of strain within these deformation limits, the smaller will be the grain-size produced by annealing.
3. The limits of the annealing range within which

this grain-growth will be produced are 650 deg. and 900 deg. C.

4. When the strain is less than a certain or "critical" amount, the annealing range seems to be limited by the thermal critical points at about 690 deg. and 780 deg. C.

5. The most practical standard by which to measure the permanent deformation seems to be the reduction of area. No grain-growth occurs following a reduction of area of less than about 7 per cent or more than about 25 to 30 per cent. The "critical" strain seems to be marked by a reduction of area of about 9 per cent.

6. The refining action taking place at about 780 deg. C. is a further indication of the presence of a thermal critical point at this temperature.

7. The presence of carbon causes a suppression of grain-growth, an effect which, while negligible when the carbon content is low, is very pronounced when the steel contains 0.15 per cent or more. No noticeable grain-growth was found to occur in steels which were uniformly above 0.18 per cent in carbon content.

Grain-growth can therefore be avoided by the application of comparatively heavy work to the metal before annealing, or by proper control of the annealing temperature. If the cold-worked metal is not annealed no grain-growth can occur.

The president, Sir Robert Hadfield, in presenting the paper, said that experiments he was carrying out showed that far below 300 deg. C. phenomena occurred in steel showing it not to be in a quiescent state. This fact was not properly appreciated, and it might explain why breakages often took place long after the material had been hardened. He wished Mr. Sherry had not confined himself to only one type of steel.

Dr. W. Rosenhain said Mr. Sherry's paper gave a new significance to the importance of "ghosts" in mild steel. In these relatively carbonaceous areas grain-growth could occur, and if this was facilitated by phosphorus the handling of mild steel needed careful watching. The annealing point recommended (650 deg. C.) was only safe in a material that did not rely on carbon content for the greater portion of its strength. It could be inferred from the paper that the theory of the existence of a thermal critical point at about 780 deg. was far from dead.

Specific Resistance of Iron.—At the eighty-first meeting of the Faraday Society in London, Dec. 18, 1916, Prof. E. D. CAMPBELL of the University of Michigan, U. S. A., presented a paper entitled "Do Equiatomic Solutions in Iron Possess Equal Resistances?" The following is an abstract of the paper, which was read for the author by Sir Robert Hadfield:

The conception of steel as a solid solution has long suggested a relationship between its chemical composition and resistance. Le Chatelier's work in 1898 indicated that equiatomic concentrations of carbon as hardening carbon and silicon exerted practically equal effect on the specific resistance, while that due to manganese was only about five-sevenths as great, that of nickel three-sevenths to five-sevenths as great, and that due to chromium, tungsten, and molybdenum was very slight. Benedicks, in 1902, laid down the general law that equiatomic solid solutions in iron possess equal resistances.

The experimental work of Arnold has shown the assumptions underlying Benedicks' law to be untenable, and the object of the author's experimental work was to seek a more satisfactory hypothesis. The experiments, which are described in the paper, were carried out on seven steels of varying compositions, and their specific resistances were measured in both the hardened and annealed states. The deviations from the calculated values cannot be explained on Benedicks' as-

sumption, but they suggest that it is the *molecular* concentration of the *carbides* in solid solution and not the *atomic* concentration of the *carbon* which determines the influence on the specific resistance exerted by such solutes.

The almost constant value of the absolute increase in specific resistance with increased temperature, this increase differing very slightly from that of pure iron, would indicate that the increase is almost wholly due to the increase in specific resistance of the solvent, while that component of the total specific resistance due to the solutes in solid solution is only slightly affected by the temperature at which the specific measurements are made.

Tungsten

Manufacture of Tungsten in England.—When the war broke out the manufacturers of high-speed tool steel in England found themselves in much the same position as the users of dyestuffs. The *Engineer* (London) states that, following a Government inquiry into the manufacture of tungsten, a committee was formed of representatives of leading steel makers and thirty-one firms took shares in a company which was formed, called High Speed Steel Alloys, Ltd. The erection of the works was commenced about the end of 1914, and by July, 1915, the production was begun. In September, 1915, the British Government took control of all wolfram ore within the British empire and divided it among the makers of tungsten and ferro-tungsten. To assist in increasing the output of ore within the empire the company purchased mines in Burma, which have been placed under the control of Dr. W. R. Jones, who was formerly in charge of the Indian Survey. Ore is also obtained from Australia, and it is hoped that before long South Africa will be another source of supply. The works of the company are now in full operation and are using the following process: The ore is crushed, ground, screened and mixed with soda. A magnetic separator is used for separating tin ore from the tungsten ore. The mixed ore and soda are roasted in coal-fired reverberatories, requiring two to three hours. The furnace product is boiled with water and the tungstate of soda dissolved. The solution is then filtered and the filtrate containing the tungsten is treated with hydrochloric acid, when tungstic oxide precipitates. This is filtered off and dried, mixed with powdered anthracite coal and placed in crucibles, which are heated in coke stoves. The last-named process will, however, shortly be improved upon as a new continuous furnace, heated by gas from two Wilson bituminous gas producers, is now being erected. The reduced metal is then washed in dish-shaped trays and dried, yielding the final product in the shape of a fine chocolate colored powder of 98 to 99 per cent purity. This is packed in tin-lined wooden boxes containing about 200 lb. ready for delivery.

Refractories

A Carbon Tube Furnace for Testing Refractories.—At the eighty-first meeting of the Faraday Society, held in London, Dec. 18, 1916, EZER GRIFFITHS and EDGAR A. GRIFFITHS of the National Physical Laboratory, described and exhibited a carbon tube furnace for testing the softening points and compressive strengths of refractories.

The paper describes a carbon tube furnace designed for the testing of refractory materials under definite load.

The specimens are cut from the brick and ground up into the form of short cylinders. Pressure is applied by means of springs suitably connected to carbon rods which carry the specimen under test.

Two simple forms of electrode construction are described. In one of them the current is carried by two copper tubes bent into a zig-zag form and cast into two blocks of white bearing metal. The faces of the blocks are cast to the form of the carbon tube to which they are clamped. The copper tubes also serve for water cooling.

The temperature of the specimen is directly observed by means of a polarizing type of optical pyrometer. For this purpose a slot $\frac{1}{4}$ in. wide extends the entire length of the tube. A slot was made in preference to a round hole, since the latter would have produced a discontinuity in the resistance of the tube.

In the discussion Dr. W. Rosenhain remarked that the results obtained depended upon the surfaces between the little columns being absolutely true. In the case of a material which softened with temperature the results would be affected by the intensity of the pressure.

Mr. H. M. Ridge said he was glad to know of an apparatus that could be subjected to over 1500° C. and at the same time give accurate tests of firebrick materials. He hoped that if comparative tests had been made on the standard bricks they would be published. The recent regulation fixing a maximum price for firebricks militated against the good brick, but enabled the maker of inferior bricks to raise his prices. The use of an apparatus like that described would enable a sliding scale to be fixed on a basis of actual tests.

Dr. H. Borns asked how long a test took.

Dr. H. C. Greenwood asked whether tests had been made on the effect of temperature on tensile strength.

Dr. R. Lessing thought the test pieces used in the furnace rather too small, especially for large-grained material.

Mr. E. Griffiths, in reply, said there was no difficulty in applying the pressure normally. Usually three specimens were taken from a brick and the results only accepted when concordant. A small test-piece ensured uniform distribution of temperature. A test usually took $2\frac{1}{2}$ hours at a 10° C. increase of temperature per minute. Comparative tests could not be published at present, but he might say that a magnesite brick broke down at 1500° C. when heated uniformly, under a pressure of about 30 lb. This was about the normal.

Electrochemistry

Electrochemical Analogies of Photochemistry.—At the Cleveland meeting of the American Physical Society, Oct. 27 and 28, 1916, WILLIAM ROY MOTT of the National Carbon Company's Research Laboratory, Cleveland, Ohio, read a paper on "Electrochemical Analogies of Photochemistry." An abstract was published in the *Physical Review* for January, 1917. The author has made experiments on dye fading and other photochemical reactions and has come to the conclusion that the general theory of the electrochemistry of photochemistry can be revised to a more concrete form than expressed by the theory of Grothuss. In the revised theory the two electrochemical factors of current and voltage are respectively related to amount of light and wave-length of light.

He first discusses the analogy of current and amount of light, citing Faraday's law and the photochemical law, that the amount of chemical action is nearly proportional to the energy of the light absorbed in the photochemical reaction chamber. The limitations of these laws, viz.: the necessity for a certain minimum voltage in Faraday's law and the wave length limits in the photochemical law are discussed.

The great importance of absorbing media in photochemistry leaves no apparent relation to electrochemical equivalents as in electrochemistry in going from

one material to a different material. The departures from apparent proportionality can be explained, however, in a manner similar to the apparent departures of electrochemical reaction from Faraday's law in a given electrolyte.

In developing the analogy of voltage and wave-length the author considers the wave length as an intensity factor of light corresponding to voltage as an intensity factor of electricity, and cites examples showing how the shorter wave length light has a greater chemical effect. The following table illustrates the generalization:

Material	Formula	Voltage for decomposition	
Calcium fluoride...	CaF_2	4.7	Most transparent to far ultraviolet.
Hydrofluoric acid...	HF	2.2	Not decomposed by far ultraviolet.
Hydrochloric acid...	HCl	1.7	Slightly decomposed by far ultraviolet.
Hydrobromic acid...	HBr	1.2	Easily decomposed by ultraviolet.
Hydroiodic acid...	HI	0.6	Easily decomposed by blue light.

A curve could probably be constructed between wave length of light required and decomposition voltage required. It is interesting to note that the extremely short waves are readily absorbed by everything except the *non-reactive* noble gases.

This theory can be further expanded to show a relationship between heat of formation (on electrochemical equivalents and refractive index and point of probable absorption of light as the curve is carried into ultraviolet region. Also, the theory has fascinating possibilities in predicting the character and probability of light production by chemical change.

Glass

Union of Glass by Heat Treatment.—A paper on "The Union of Glass in Optical Contact by Heat Treatment" was presented at the Faraday Society meeting in London, Dec. 18, 1916, by R. G. PARKER and A. J. DALLADAY. The paper gives the results of some interesting experiments on joining glass.

Two pieces of glass in optical contact can be made to join completely, and become one piece, by carefully controlled heating. The temperature employed is very far below the melting point, being 80 – 90° C. below the annealing point; the glass components therefore unite without softening and without deformation of unsupported optically worked surfaces. Slight pressure is usually applied. The components, after treatment, are not separable by any of the means which suffice to separate pieces in optical contact, viz., by liquids (capillarity), by sudden small temperature changes, or by mechanical force. When subjected to the last of these, or cut with a diamond, a composite block breaks as would one piece. The accuracy of the parts is unaltered by the heating, and it is not difficult to prepare by this method cells having windows parallel to one second, with optically worked surfaces in the interior. Within limits, different kinds of glass can be joined; their expansion coefficients must not differ greatly, nor must the annealing points differ by more than 50° C.; they must also be kinds which will fuse together in a blow-pipe flame. Only when the components are all of one kind of glass can the composite article be freed from strain by annealing. Fused silica plates unite at 1030° C.

Dr. W. Rosenhain regarded the authors' results as a remarkable achievement. He thought that various methods of polishing might make a difference in the behavior of the glass. He discussed the behavior of moisture or hydrated films as affecting the union.

Might not chemical cleaning give better results than mechanical?

Professor Alfred W. Porter thought the fact that the outside surface film of the glass was in a totally different condition from that of the inside was responsible for the possibility of the process. The outside film would be practically in a flowing state.

Mr. Dalladay, in replying said chemical cleaning might be useful, but it had not when tried given good results. Such trouble as occurred was caused by little pieces of cellulose left from the material used for wiping the surface.

Transportation

Transport of Corrosive Liquids by Water.—The transportation of acids and other corrosive chemicals has always been a difficult problem. In the *Journal of the Society of Chemical Industry* for December 30, 1916, H. N. MORRIS describes a method of transportation in a tank boat, following out the ideas of the oil tankers developed 10 years ago by the Standard Oil Co. He reviews the common methods of transporting acids at sea and shows that they are in general costly and dangerous to the ship, although cases are known where no accidents have occurred for many years. At the best the methods are, however, very costly. The author describes a proposed design for what he terms a "sub-aqueous acid tank," consisting of two shells or tanks, one within the other. The inner tank, which carries the corrosive liquid, may be suitably lined with lead, aluminum, bitumen, or materials depending on the liquids to be transported. By towing this tank, a safe and economical means of transport is provided. A light on the tank is required to safeguard against loss.

A tank of 250 tons of ordinary conc. H_2SO_4 is described, which could be used equally well for oleum, which would solidify, but could be easily melted by passing steam into the outer case until the contents of the inner tank were liquid. In this case it would be better not to line with lead, but to use stronger iron.

It could also be used for hydrochloric acid if the lead lining were covered with a uniform coating of bitumen. It could be used for the conveyance of nitric acid if lined with aluminium. As the inner tank is divided into three compartments three different acids or corrosive liquids could be transported at once.

In many cases a return cargo of oils or other liquids could be obtained. The tank is not suitable for very small quantities, but for short distances, 100-ton or even 50-ton tanks might be used economically, and there are not many countries where it would not be possible to dispose of 250 tons of either sulphuric acid or mixed consignments. The tank can be used for many acids and other chemicals: sulphuric acid, oleum, hydrochloric acid and nitric acid, carbon bisulphide, alcohol, benzol, toluol, or naphtha, which, although they cannot all be classed as corrosive, are more or less dangerous for a steamship company to carry.

New Swedish Nitric Acid Company.—A new company with large capital has been formed for the manufacture of nitric acid and other chemical products in Sweden, according to the *Chemical Trade Journal*. It has entered upon a contract with the Royal Waterfalls Board for a supply of electric energy, and the works will be erected on the area reserved for industrial installations at Trollhattan. The annual capacity will be some 7000 tons concentrated nitric acid, with nitrates as an auxiliary product. The new company will use the Birkeland-Eyde method, for which rights have been secured for Sweden. The work is being pushed ahead with all speed to be ready this year.

Recent Metallurgical and Chemical Patents

Copper

Hydrometallurgy of Copper.—A patent was granted to EDWARD RAY WEIDLEIN, of Thompson, Nev., for the extraction of copper from its ores by means of sulphuric acid and the precipitation of the copper from the sulphuric acid by means of sulphur dioxide, according to the equation, $\text{CuSO}_4 + \text{SO}_2 + 2\text{H}_2\text{O} = \text{Cu} + 2\text{H}_2\text{SO}_4$.

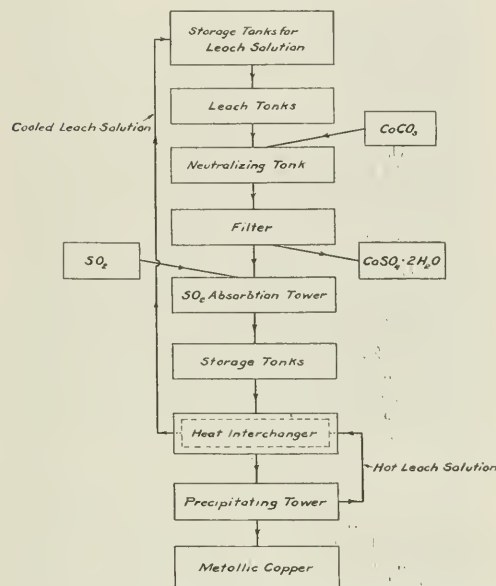


FIG. 1.—PROCESS FOR EXTRACTING COPPER

Fig. 1 represents the flow sheet of the process. In preferred practice the ore is leached with a 3.6 per cent sulphuric acid solution, the solution is then neutralized and the copper sulphate solution containing about 1.5 per cent copper is treated with an approximately equal amount of sulphur dioxide. The solution is then heated in the precipitation tanks to 150 deg. C. at a pressure of about 100 lb. per square inch. Under these conditions the copper will be precipitated. It is removed by filtration, and the solution is re-used for leaching. The process, it is claimed, may be used on ores, mattes and other copper bearing materials. (1,201,899, Oct. 17, 1916.)

Method of Connecting Electrodes in Electrolytic Refining.—ROBERT L. WHITEHEAD of Perth Amboy, N. J., has been granted patents on a method of arranging the electrode connections in a series of electrolytic vats, and on a method of making the individual contact. The method was developed in connection with the electrolytic refining of copper. The patents have been assigned to the American Smelting & Refining Company of Maurer, N. J. The original application was filed in February, 1913, containing claims to both the form of contact and the manner of arranging the connections. The application was subsequently divided and these two claims presented in separate applications. The method of arranging the connections is to connect the cathodes of one vat directly to the anodes of the adjacent vat, instead of as heretofore having two sets of contacts along the common bar supporting the cathodes of the first vat and the anodes of the second vat.

By connecting the cathodes of one vat directly to the anodes of the second vat the common busbar is dispensed with and the number of contacts is reduced to one-half. The connection, which is the subject of a second patent, is made by cutting a V-shaped groove in one electrode and making a projection on the other electrode to fit into this groove (1,206,963-65, Dec. 5, 1916).

Alloys

Nickel-Chrome Alloy.—An alloy of high melting point and high resistance to the dissolving action of acids and alkalis has been patented by THEODORE B. BRIX of Newark, N. J. It consists of not less than about 55 per cent of one of the metals of the nickel group, from 15 to 35 per cent of chromium, chromium and tungsten or chromium and titanium and not over 10 per cent of silicon. Usually nickel, chromium and silicon are the constituents used, but for certain purposes, cobalt may in part replace the nickel, or combinations as mentioned may replace the straight chromium. In varying the metals, high resistance to temperature, insolubility in acids and alkalis, malleability or ductility may be attained. Other metals such as copper, boron, aluminium and manganese may be used in small amounts. The preferred alloy, embodying practically all the desired properties, is given as from 60 to 75 per cent by weight of nickel, 15 to 20 per cent of chromium, 5 per cent copper, 4 per cent silicon, 1 to 4 per cent tungsten, 2 per cent aluminium, 3 per cent manganese-titanium (2.3 manganese) and 1 per cent boron. A method for the production of said alloy is described. (1,203,180, Oct. 31, 1916).

Sintering

Method and Apparatus for Sintering Metals.—An apparatus for the sintering of metallic powders, such as tungsten, has been patented by RAYMOND B. WALLING of Newark, N. J. Fig. 2 represents the apparatus employed. The apparatus proper is enclosed in a copper treating bottle, cylindrical in shape. The bottle is provided with a jacket 2. Between the jacket and the

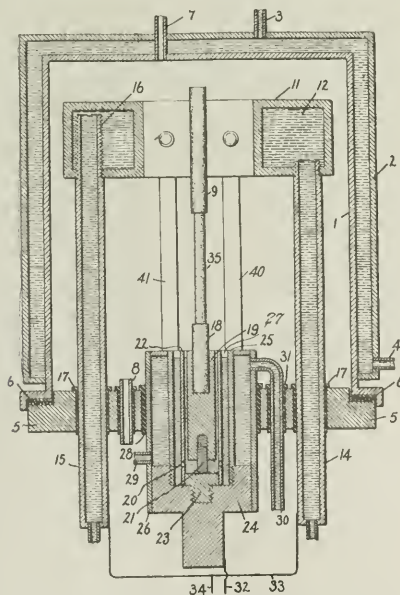


FIG. 2—SINTERING APPARATUS

bottle is a space for the circulation of a cooling medium, such as water, which enters at pipe 4 being discharged through 3. In its lowered position the bottle rests on plate 5 and is rendered gas-tight by gasket 6. During the process of operation, hydrogen gas or some other inert gas is circulated through pipes 7 and 8; 9 is the upper electrode and is made of the material which is to be sintered (in this instance tungsten), the electrical contact being made with copper clamps 10 and 11. Cooling arrangements are provided for the electrode holders; 18 is the lower electrode, and is firmly set into the copper casting, which floats in mercury bath 20; 21 is a screw which regulates the height of the mercury and also the downward motion of the electrode 18. Cooling devices are also described for this electrode. 35 represents the tungsten rod which is to be sintered by means of heat generated by the resistance of the passage of an electric current through the rod. The main features of this apparatus are the use of the electrical current and the floating mercury contact for the lower electrode. It is claimed that by using this method there is no waste whatever, as the rod is perfectly sintered throughout its entire length (1,194,906, Aug. 15, 1916).

Apparatus for Roasting and Sintering Ores.—A patent granted to JAMES GAYLEY of New York, N. Y., involves improvements made on the Dwight-Lloyd type of sintering machines. The main feature of the improvements consists in making the joints between the moving pallets and the wind box automatically tight, thus preventing the impairment of the airtight union between the two. Fig. 3 represents the longitudinal

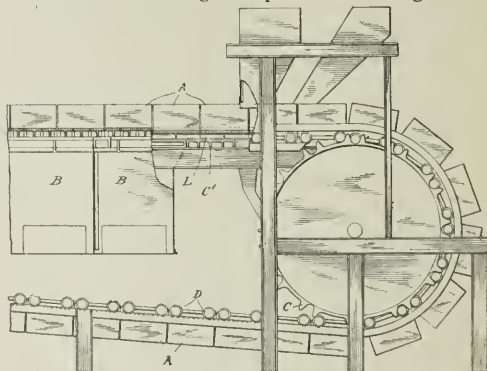


FIG. 3—ROASTING APPARATUS

section of a part of the machine and Fig. 4 is a vertical cross-section of the same. A train of pallets A moves continuously over the top of the wind box B. The means of locomotion of these pallets is similar as in the Dwight-Lloyd machine. The whole length of the wind box top is fitted on either side with a rectangular wearing bar F, and at each end it is filled with a dead plate

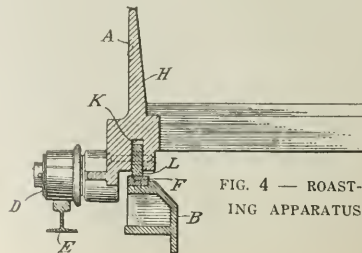


FIG. 4—ROASTING APPARATUS

C', over which the whole width of the pallet slides to prevent the leakage of air at these points. The wearing bars constitute the fixed member of the sliding joint which is maintained between the pallets and the wind box. Bars or plates fit in grooves *K* in the under surface of sides *H*. These bars or plates are termed curtains and are designated as *L*. In their simplest form these curtains consist of rectangular plates or bars, having the same length as the pallets. These plates or bars fit into the recesses in the pallet with only sufficient clearance to permit free movement of the pallets under their own weight. *M* are rods or pins which prevent the endwise movement of the curtains in the pallets. These improvements, it is claimed, give the desired automatic airtight joint (1,197,199, Sept. 5, 1916).

The Utilization of Waste-Products and of Low-Grade Fuels for Power-Generation

By John B. C. Kershaw, F.I.C.

TOWNS' REFUSE

The rising cost of all classes of coal and slack due to causes, some permanent and some we may hope only temporary in character, but which it is unnecessary to analyze here, renders the discussion of the utilization of waste materials and low-grade fuels for power purposes of particular value at the present moment. The power engineer has been badly hit by the increase in the cost of fuel, and since it is highly probable that a large share of this increase will prove to be permanent, it is necessary that he should take a wide survey of all combustible materials, and impress into his service any that promise to yield a fair return for their cost of collection and cartage, as fuel for his plant.

Foremost among the waste materials that may be utilized as substitutes for ordinary fuel, is that of towns' refuse, since not only is its quantity large, but its destruction by burning is imperative in all large towns and crowded centers of population. Further, the heat produced by its combustion is most easily utilized by means of steam boilers and electrical generators, and the slag produced by its combustion may also prove a valuable source of revenue.

In this article the writer proposes to discuss:

1. The published data relating to the calorific value of this refuse for steam raising purposes.
2. Recent improvements of the destructor process.
3. The practical value of refuse destructors from the standpoint of the power engineer.

I. THE CALORIFIC VALUE OF TOWNS' REFUSE

It must be admitted that many of the published figures relating to the calorific value of towns' refuse are unreliable and misleading and that some of the earlier estimates of the number of kilowatts that might be produced from a ton of refuse were much too high, and have only been approached in specially situated districts where the calorific value of the refuse is unusually good.

Towns' refuse is a product that varies greatly in composition and value, not only in different towns, but also in the different districts of the same town, and at different periods of the year. The only figures that are reliable as to its calorific value therefore, are those based upon twelve months' operation of the destructor plant, since the summer value of the refuse is generally lower than the winter.

In colliery districts where the miners' families obtain their coal for nothing, or at a nominal price, and the general public pay only about one-half of the price charged to the consumers in large towns, the fuel value

of the refuse will also be twice as high, owing to the presence of much unburned carbon in the cinders.

In towns and cities far from coal-mining districts on the other hand, the refuse will be found to consist largely of kitchen and garden garbage, which, if wet, has little value for steam-raising purposes.

Bearing these facts in mind, one can now proceed to examine and analyze the figures obtained in tests of the more recently erected destructor plants, with a view to ascertaining the real fuel value of the refuse collected from a town of average size. The figures presented are mostly those obtained during test runs of the plant when taken over from the engineering firm which designed and erected it, and a standing deduction of 33.3 per cent will be made from these figures, in order to bring them into line with the results that may be expected from twelve months' practical operation of the plant. This percentage deduction has been arrived at by study of the comparative data published in the early years of destructor development for short test runs, and for one year's operation of combined destructor and electric generating plant.

THE HORSFALL DESTRUCTOR

"The New Destructor Company," who now control the Horsfall system of refuse destruction give, in a recent publication, a tabular statement showing the gradual improvement in the efficiency of their destructors during the period 1900-1910. The results are based on tests of not less than twenty-four hours' duration, and the water evaporated per pound of refuse shows an increase from 1.21 lb. for the destructor erected at the Pembroke Electricity Works, Dublin, to 1.57 lb. for the Poplar Electricity Works, in 1910. The details of this latest available test for the Horsfall type of destructor are as follows:

Place—Poplar.

Date of test—Feb.-March, 1910.

Tons of refuse burned per twenty-four hours—153 tons.

Evaporation per pound of refuse at 212 Fahr.—1.57 lb.

The adoption of closed tubes with hopper bottoms for storing the refuse at the destructor plant until charged into the furnaces, and of a mechanical clinkering grate in the form of a tipping truck, are the latest improvements of the Horsfall Destructor.

THE HEENAN AND FROUDE DESTRUCTOR

The following results of recent tests with the Heenan and Froude type of refuse destructor are of special interest, since they emphasize the great variation in the thermal value of the refuse in different parts of the country, and illustrate the remarks made on this point in the introduction to this article.

Town	Date of Test	Period of Test	Lbs. of Water Evaporated per Lb. of Refuse
Aberdare (S. Wales)	March 24, 1915	10 hours	3.53
Pontypridd (S. Wales)	Feb. 10, 1910	8 hours	2.69
Coventry	April, 1911	48 hours	2.00
Rotherham	Jan. 27, 1910	18 hours	1.80
Clydebank	May 2, 1907	8½ hours	1.73
West Bromwich		8½ hours	1.15
Swinton	Sept. 24, 1912	11 hours	1.32
Cheltenham	June 26, 1908	17½ hours	1.24
Rotterdam	Feb. and May, 1913	6 days	1.10
Rotterdam	Feb. and May, 1913	10 days	.88

N.B.—These are actual evaporations, and are not expressed on the standard basis "from and at 212 deg. F."

The adoption of water-sealed charging devices, and of improved methods of withdrawing and quenching the clinker, are some of the latest improvements in the Heenan and Froude type of destructor.

FOREIGN TYPES OF DESTRUCTOR

The first destructor erected in Germany was that at Hamburg in 1896, a result of the cholera epidemic in the previous year. This was of the Horsfall type, and some trouble due to the use of steam jets was experienced before it worked satisfactorily. Brussels followed the example of Hamburg in 1903, and Zurich in 1904, by erecting similar destructor plants. These were also of the Horsfall type. The first German-designed destructors were those erected at Wiesbaden by Dörr, and at Kiel by Herbertz, in 1905-1906. These designers made use of the principle of using hollow chambers in the walls of the destructor cell for the purpose of heating the incoming air, which was forced by fans into the combustion chamber under a pressure of 400 mm. (16 in.) water.

As might be expected from the methods of domestic heating in use in Germany (by closed stoves using chiefly briquette-fuel) the refuse collected in German towns and cities is less rich in combustible material than English refuse. At *Puchheim*, the evaporative efficiency is 0.891 lb. of water per pound of refuse, (equivalent to 1.01 lb. from and at 212 deg. Fahr.) while at *Fürth* (Humboldt system) the actual evaporative efficiency is 0.98 lb. water per pound refuse, equivalent to 0.97 lb. from and at 212 deg. Fahr. The general results obtained at these two installations show that German refuse has an average heat value of only 2160 B.t.u. per pound, and that about one-half of this heat value can be utilized for steam-raising purposes.

The English figures, consequently, show much higher evaporative efficiencies, the average for the Heenan and Froude type of destructor being over 1.87 lb. water per pound of refuse and that for the Horsfall destructor being 1.38 lb. Taking 33.3 per cent off these figures we have 1.25 and 0.94 lb., respectively. It is unlikely, however, that in view of the increased price of fuel in recent years and the urgent necessity for the practice of economy on the part of all sections of the population, that English house refuse will in future contain so much cinder and unburned carbon as in the past, and it will be wiser, therefore, to assume that the average calorific value of towns' refuse, when calculated upon twelve months' working of the destructor, is about 2160 B.T.U. per lb., and that only 1 lb. of water can be evaporated per lb. of refuse burnt, for steam-raising purposes. The practical application of these figures will be discussed in the third portion of this article, when discussing the generation of electricity from house refuse.

II. RECENT IMPROVEMENTS AND THE CONTROL OF THE DESTRUCTOR PROCESS

The difficulties met with in the destruction of house refuse by burning are chiefly those arising from the physical character of the materials to be consumed, and the large amount of clinker produced as a result of the combustion of the refuse. Kitchen garbage and similar refuse is generally wet, and will not burn at all until dried, while the rags, waste paper and cinders, that form the other chief combustible elements of the refuse, are so distributed and buried among the mass of incombustible material that it is very difficult to get an adequate air supply at the points where it is most required. According to Broadbent, the average composition of London refuse is as follows: Ash, 47 per cent; breeze and cinder, 25.5 per cent; paper, straw and vegetable refuse, 13 per cent; dust and dirt, 9.75 per cent, while the remaining 4.75 per cent is made up of bones and offal, rags, bottles, crockery, broken glass and tin cans. The combustible material, therefore, does not amount to more than one-third of the whole, and

the difficulties of burning it are much greater than those encountered in burning the poorest qualities of slack or coke breeze containing 30 per cent to 35 per cent of ash.

When the combustion has been successfully effected the fused clinker that remains behind is over one-third the weight of the original charge of refuse, and special forms of grate and special appliances are necessary in order to deal with this large amount of molten matter and to avoid heat losses by its withdrawal from the furnace.

The difficulties of attaining complete combustion have been overcome by the use of fans for supplying preheated air under considerable pressure, perforated iron plates being employed for the furnace sides and bottoms in many of the newer types of destructor in order to distribute this air through the whole mass of material to be burned. The air is preheated either by passing through the hollow well spaces between the different cells of the destructor or by special air heaters placed in the hottest part of the combustion chamber of the furnace. It is now recognized by designers of destructor cells that a preheated air supply is a *sine qua non* of good destructor working, for a difference of 300 deg. C. in the temperature of the incoming air makes a difference of 350 deg. to 400 deg. C. in the actual temperature attained in the furnace. The advantages of a preheated air supply are not confined to this increase of thermal efficiency, for a quicker ignition of the refuse and an accelerated combustion accompany the use of hot air, and the capacity of the destructor per day of twenty-four hours is therefore greatly increased.

As regards the improved methods of dealing with the clinker, it has been found by actual measurements that the heat retained in the fused mass only amounts to from 3 per cent to 4 per cent of that generated, and attempts to utilize this heat for raising the temperature of the incoming air or for other purposes have not proved so successful as was hoped. The use of water-cooled mold-shaped grates which facilitate the removal of the clinker in one mass and of a bar bent in a spiral form around which the clinker melts are the latest devices for dealing with the clinker problem, since by means of a ring-shaped handle to the clinker bar and a winch a mass of fused clinker weighing several hundredweights can be removed from the furnace with ease by one man.

As regards charging the refuse into the destructor, the double-bell system has been improved upon, a whole charge now being dropped into a water-sealed pocket in one operation before the lower bell is raised and the charge is passed on into the furnace.

The latest development of destructor design, however, is the adoption of the blast furnace as the model of what a refuse destructor should be, the Dörr destructor erected at Wiesbaden being the first of this type. Improved forms of the shaft type of destructor have been erected at Barmen and Hamburg, and as these represent a distinct departure from the ordinary type of destructor design, and can be operated with reduced costs, a few details of their construction and method of working are appended. The original Hamburg furnace was constructed in the form of an octagonal shaft, the hearth of which was rectangular in form and water-jacketed for cooling purposes to prevent the clinker adhering to the walls. A perforated iron gating was used for distribution of the air supply, and a fan supplied air under pressure to the air chamber below the grating. This furnace gave a mean temperature of 1050 deg. C. and burnt successfully 31 tons of refuse per day.

An improved form of the Hamburg shaft furnace

was erected later at Barmen. In this case a preliminary grate was provided in front of the grating of the shaft furnace, and on to this the clinker cake was drawn and remained twenty to forty minutes, in order that it might give up some of its heat to the incoming air. As already stated, the heat losses with the clinker are small and the temperature of the incoming air cannot be raised to any considerable extent by contact with it.

The latest types of the shaft destructor furnace have, therefore, adopted special air heaters placed in the hottest part of the system for preheating the air supply, and only use the clinker heat for the preliminary step in the preheating process.

Kohlmann,* in a valuable paper upon the "Evolution of the Refuse Destructor," read before the Canadian Section of the Society of Chemical Industry in 1913, has given the following figures for the capacity of the various types of destructor, and if these can be accepted as reliable the superiority of the shaft type of furnace with preliminary air heating is amply demonstrated. The fact that with this type of furnace the labor costs for charging and removing the clinker are also reduced to a minimum would indicate that in time we may expect to find all dust destructors approximating to this type of design.

System	City	Grate Area Sq. Metres	Capacity per Hour per Sq. M. of Grate
Horsfall	Hamburg (old)	2.75	76 1133
	Zurich	1.89	133
	Brussels	2.5	133
			220
Heenan	Milwaukee	2.5	335
	Dublin	2.7	260
	Cheltenham	2.7	235
	Vancouver	3.0	255
	Coventry	2.7	385
Herberts	Fiume	1.25	345.75
	Brann	1.25	325
	Kiel	0.94	445
	Frankfurt	1.1	285
		2.2	480
Humboldt	Furth	1.5	720
Lörr	Wiesbaden	1.0	815
Hamburg	Hamburg (new)	1.2	1530

III. THE PRACTICAL VALUE OF REFUSE DESTRUCTORS FROM THE POWER ENGINEER'S STANDPOINT

The figures given in the first section of this article prove that house refuse has an average heat value of one-seventh that of ordinary coal, and that about 1 lb. of steam can be produced per pound of refuse burnt. Has such a poor fuel any value at all from the power engineer's standpoint? If this question were decided solely upon the value and merits of this refuse as a fuel, the answer to the question would be in the negative, for the interest upon the capital outlay on the destructor plant and the costs of working it would amount to more than the value of the steam produced. But, as pointed out in the introduction to this article, the question of refuse destruction by burning is fundamentally a sanitary one. All large towns and cities ought to be provided with destructors with sufficient capacity to cremate the whole of their refuse, and the question of utilizing the surplus heat to the best advantage is really an economic one, bound up with the successful operation of these plants.

In the early days of destructor development it was customary to erect and work these plants as adjuncts of the electricity supply stations, and it was claimed that from 40 to 60 units of electricity could be obtained in these combined plants per ton of refuse burnt. The

L. S. D. value of the latter as fuel was calculated therefore to be 3s. 4d. (\$.80) per ton.

The electrical engineers in charge of large power-generating stations, however, were not in favor of the system, since a certain amount of nuisance and dust detrimental to the efficient working of the machinery arose from the carting and tipping of the refuse, and only a few of these combined plants have been erected in recent years.

The modern plan is to erect the destructor on the site most suitable for the collection of the refuse, to operate it as an independent works, and to sell the steam produced by the surplus heat to the nearest factory or works at an agreed rate per 1000 lb. In some cases this sale is to an electricity supply station, but this is not an essential feature of the plan, and any large works that requires steam for heating or power purposes might cover a portion of its requirements from a destructor plant if one were near at hand. As examples of this system of working, the destructor plants at Huddersfield, England, and at Rotterdam, Holland, may be referred to.

The Huddersfield destructor was erected in 1910 by Manlove & Alliot of Nottingham, and consists of eight furnaces or cells, arranged in two units of four cells each, each unit being complete with its own combustion chamber and water-tube boiler. The cells are of the "back-feed" type, and are arranged on the continuous system. Each cell has a grate area of 25 sq. ft. and is provided with a drying hearth at the rear, where the green refuse is subjected to a preliminary drying. Forced draught is provided by two electrically driven fans, and the air is preheated before its entrance into the combustion chamber. The surplus steam not required for the operation of the destructor plant is carried by well-insulated steam mains over a roadway to the electricity works, and is sold to this undertaking at a net cost of 7d. (14 cents) per 1000 lb. The annual revenue received by the destructor plant from this source in the four years 1911-1914 has been as follows: 1911, \$7,525; 1912, \$8,795; 1913, \$8,950, and 1914, \$8,505.

The Rotterdam plant was erected in 1911, and was first put into operation in 1912. The destructors are of the well-known Heenan & Froude type, and are provided with all the improvements brought out by this firm in recent years. The plant consists of five independent units, each consisting of two sets of four cells, grouped on either side of a central combustion chamber. The grates of four adjoining cells are separated from one another by low cast-iron transverse dead-plates of hollow construction, so that the four grates practically form one continuous furnace chamber.

Each unit is fitted with a "regenerator" consisting of a group of vertical boiler tubes expanded at the top and the bottom into horizontal tube-plates. The hot gases from the boilers pass through the tubes and down into dust pits, while the draught air passes over the outside of the tubes.

The most striking feature of the installation, however, is the system of collecting the house and street refuse of the city and of bringing it to the destructor furnaces with a minimum of nuisance and cost. The city is divided into five districts, in each of which there is a small dock for accommodating barges. To these docks the refuse is brought in tip-carts, which tip the refuse direct into skips, a number of which fit neatly into a barge. The refuse never leaves these skips until it goes into the furnaces. Each barge holds about 2 dozen skips and each skip contains about 1600 kg. (31.5 cwt.) of refuse. The skips have bottom doors, which can be tripped when the device is lowered into its seat-

*Journal Soc. Chem. Industry, April 30, 1914.

ing over the furnace; also they are made larger at the bottom than at the top, so that the rubbish will fall out quite readily.

It is chiefly in this respect that the older systems of destructor working were faulty and capable of improvement, and although the possession of canals that ramify all through the city simplifies the collection and transport of the refuse in Rotterdam, there is no doubt that many of the good points of the Rotterdam system might be copied with considerable success in other towns and cities.

The official trials of the plant, made during separate runs in February and May, 1913, showed that 1214 tons and 1228 tons of refuse had been cremated, with an evaporation of 1.106 lb. and 0.889 lb. of water per pound of refuse burnt respectively, an average of 144 tons per day, and 0.99 lb. steam for the whole seventeen days' period of trial. The steam raised is used partly in the plant where the clinker is crushed and graded to three sizes, and all iron is removed by magnetic separators, while the surplus is sold to the municipal electricity supply department at the fixed rate and is used for driving a 1250-kw. turbo-generator.

The city electricity department provided half the capital required for the electrical portion of the plant and for the building in which it is housed, pays the whole of the running charges of the same, and 0.10 penny (0.20 cent) per unit for the steam. Further details of this interesting plant will be found in the descriptive article from which these facts are taken, which appeared last year in the publication referred to below.*

The one disadvantage of the Rotterdam system of working appears to be that there is no opportunity for sorting the refuse and removing from it the paper, old metals and broken glass, all of which have a marketable value, especially at the present time.

As an indication of the annual revenue that may be derived from this source by a destructor plant, the following figures from the 1914 report of the chief sanitary inspector of Paisley in Scotland, are of interest: 17,576 tons of refuse, or an average of 50 tons per working day, was collected and dealt with in 1913, and 3177 tons of clinker and 243 tons of mortar were sold in that year.

The revenue of the destructor plant from the sale of the residual products was as follows:

Clinker	\$1,120
Mortar	240
Old tins and scrap metal	546
Waste paper	76
Old bottles	20
Total	\$2,006

In view of these figures, and of the fact that the relations between the sanitary and electrical departments at Huddersfield and Rotterdam are most harmonious, it would seem probable that a considerable increase will occur, during or after the war, in the number of destructor plants for towns' refuse equipped with the most efficient types of furnace, and that these plants will all derive considerable revenue from the sale of their surplus steam to the neighboring works and from the disposal of their clinker and other by-products to those who can make good use of these commodities in their operations.

If the experience of Huddersfield and of Paisley is a safe guide, an aggregate revenue of between \$11,800 and \$14,400 can be obtained in all large cities from these two sources alone, and a considerable portion of the cost of destroying the refuse can thus be met.

Personal

Prof. Wilder D. Bancroft was in New York on Thursday, Feb. 8 and delivered a lecture in the evening at Columbia University on "Contact Catalysis" under the auspices of Gamma chapter, Phi Lambda Upsilon, and as a part of the extension teaching course.

Dr. V. A. Coulter has been appointed assistant professor of chemistry at the University of North Carolina.

Mr. Samuel H. Dolbear, consulting mining engineer, has removed his offices to 1411-12-15 Merchants' National Bank Building, San Francisco.

Mr. Gustav Drobegg has resigned his position with the Beckers Aniline & Chemical Co., Inc., to accept the superintendency of plant D of the Butterworth-Judson Corporation, at Newark, N. J.

General Geo. W. Goethals has opened consulting offices in the Wall Street Exchange Building, 43 Exchange Place, New York. A number of experienced specialists are associated with him, and a general consulting practice in civil, electrical, mechanical and hydraulic engineering will be engaged in.

Mr. Walter Kidde, engineer-constructor, of 140 Cedar Street, New York, has incorporated his organization under the title of Walter Kidde & Co., Inc. The business was established in 1900 and has grown steadily. One of their most recent commissions is the plant of the American Hard Rubber Co., at Akron, Ohio. Mr. Kidde's chief associates, who have been his partners on the "Carnegie Plan," will now become directors and stockholders of the new corporation, the officers of which are: Walter Kidde, president; B. G. Worth, vice-president; I. R. Lewis, secretary and treasurer. These are all members of the board of directors, which also includes Henry Lang, who is vice-president of the Ingersoll-Rand Company, and E. S. Boyer, who is associated with the American Hard Rubber Company. Mr. Kidde's other principal associates, who comprise the engineering board of the corporation, are: A. B. Miller, Walter S. Wainright, M. I. Buttfield and E. Schwarz. The chief draftsman is Thorlief Fliflet.

Mr. A. R. Levin has become associated with the Supplee-Biddle Hardware Company as manager of the New York office, 30 Church Street.

Mr. O. C. Martin, who has been with the Nichols Copper Co., Laurel Hill, Long Island, for several years, has been made works manager of the company.

Mr. John G. Mason has become associated with Ralph L. Fuller & Co., Inc., 20 Rector Street, New York, as manager of their chemical and drug division.

Mr. J. Henry Rickard has recently returned to England from the United States.

Dr. A. H. Ney announces that he is in no way now connected with any consulting business or laboratory, firm of chemical engineers or manufacturers of chemical apparatus, and that any such connections which have existed, have been discontinued. His entire time is taken up with work in connection with the development of the chemical products and dye manufacturing plant of the Sherwin-Williams Company, of which he is the head, and he is not willing to consider propositions for his services in any form whatsoever, matters pertaining to national defense or economical development of the national resources alone excepted.

Mr. Paul Noble, recently with the Bayer Company, has become sales manager of the American Aniline Products, Inc., whose office has been removed from

15 East 12th Street, to 120 Hudson Street, New York City.

Professor E. F. Northrup, research physicist of Princeton University, has been awarded the Elliott Cresson medal by the Franklin Institute "in recognition of his electrical inventions and high temperature investigations."

Mr. Robert Carl Schroth, Jr., president of the Laboratory Supply Co., of Columbus, Ohio, and Mr. C. D. Fraunfelder, president of the Ohio Pottery Co., of Zanesville, Ohio, were in New York and attended the meeting on "Chemical and Electrical Porcelain" held at the Chemists' Club on Friday, Feb. 9. Both report great activity in their line.

Mr. A. M. Webb, assistant manager of the Chemical Construction Company, was married on January 11, to Miss Jean Harper, at Charlotte.

Professor W. M. Weigel has resigned as professor of mining at Pennsylvania State College, to become superintendent of the concentrating mills of the International Molybdenum of Renfrew, Ont.

Book Reviews

Pipe and the Public Welfare. By R. C. McWane. 165 pages, illustrated. Price, \$1.00. New York: The Stirling Press.

This little volume was written for the purpose of showing the advisability of using cast-iron pipe for conduits and contains much that is of historical and practical interest. The author first discusses the history of the use of pipe in an interesting manner, beginning with the crude clay pipe of early Babylonian days, 4000 B. C. The history covers the introduction and development of iron and wood pipe, accounts of the water-supply systems of the large cities, and the use of iron pipe for gas mains. He then gives a review of materials and methods used in making metal pipe, which is followed by a long discussion on metal pipe deterioration, the latter being mostly in the nature of practical evidence of the rust-resisting qualities of cast iron. The last chapter is devoted to a discussion of the use of wood pipe. Concrete and clay pipe are purposely omitted, as these are not used to any extent in pressure conduits. Many interesting illustrations are included in the book.

Selling Your Services. By the Sales Service Company. Price, \$1. New York: The Sales Service Company, 627 Madison Avenue.

It is a little difficult at first for a technical man to think of his services or ability as a distinct commodity which can be marketed according to accepted principles of salesmanship. Yet here is a delightful little book which says that this is true and shows how to apply these principles to the obtaining of a position by a technical man. It is written in a convincing manner with many typical letters, and entirely from the salesman's viewpoint on accepted business principles.

A Text Book of Inorganic Chemistry.—Vol. VIII: The Halogens. By G. Martin and E. A. Dancaster. Crown octavo (15 x 22 cm.). 337 pages, 30 illustrations. Price, \$3. London: Charles Griffin & Company, Limited. Philadelphia: J. B. Lippincott Company.

Although numbered VIII in the series, it is the second to be issued. The other volumes are in preparation or in press. Both the editor of the series, Dr. J. Newton Friend, and the immediate authors of this volume emphasize the idea that the work is not intended to be exhaustive, that technical details are briefly touched

upon, and that most attention is given to the chemical and physical properties of the elements concerned and their compounds. The consequence of applying these principles is that the work is neither one thing nor another, neither an inspiring text-book nor a complete hand-book, but it has a certain value as a reference book if completeness is not expected, and from this viewpoint the present volume on halogens is not without merit.

The Mineral Industry: 1915. Edited by G. A. Roush. Octavo (15 x 23 cm.), XX + 941 pages; price \$10. New York: McGraw-Hill Book Company, Inc.

Volume XXIV looks as important and portly as its noted predecessors, while its pages, on inspection, bear out the statement that in quality of content it is the equal of its ancestors. There is not much need to praise it further than this, except to remark that the gathering of foreign data and statistics for 1915 was necessarily a work of the greatest difficulty, and everyone consulting the work will be impressed with the success attending the editor's efforts under such unusual handicaps.

Many of the regular contributors are represented (they are too many to catalog in a review), but several new and familiar ones have been added to the galaxy, such as J. W. Beckman on "Borax and Potassium Salts," R. M. Keeney on "Radium, Uranium and Vanadium," E. H. Leslie on "Gold and Silver in Mexico," E. S. Moore on "Gold and Silver in Australia and India," Balfour Scott on "Tin," L. O. Snyder on "Gypsum in Oklahoma," M. W. Von Bernewitz on "Gold and Silver in the United States," and on "Flotation."

Report on the Fertilizer Industry. By the Federal Trade Commission. U. S. Government Printing Office, August, 1916.

This 290-page report, prepared mostly by E. O. Merchant, F. L. Hawes and W. W. Bays, is full of valuable information, systematically arranged and written with judgment and snap. The successive chapters deal with inorganic nitrates and ammoniates, organic ammoniates, phosphates, potash salts, and mixed fertilizers. The technical, the commercial and the financial aspects are all fairly considered and skillfully interwoven. It constitutes a valuable contribution to the literature of this important industry, useful alike to the scientist and the farmer, the technologist and the business man. But it is an open question whether the report has not gone too far in divulging what might be considered "trade secrets" in fairness to the commercial interests concerned.

CURRENT MARKET REPORTS

The Iron and Steel Market

Germany's announcement of unrestricted submarine warfare, made public on the first of the month, was followed by a sudden and sharp decrease in inquiry for steel products. The market had already become relatively quiet in this respect in the fore part of December, on account of the German peace proposal, the close approach of the holidays and the influence that business engagements had already been made very far ahead. During January there had been no sign of the increase in market activity that usually follows the holiday period.

No noticeable decrease in the filing of specifications against old contracts followed the German announcement, nor was there any relaxation in the pressure exerted by buyers for heavier deliveries of material against old contracts. Buyers required time to reach conclusions as to what effect upon steel conditions would

be exerted by the probable consequences of Germany's action. Their conduct showed clearly that it was purely a case of taking time to consider. They would not make new engagements and they would not relax their efforts to continue the business they were conducting.

What occurred was exactly what would be expected of the steel market. It is sensitive in its way, but it is not sensitive like the non-ferrous metal market in respect to exhibiting price fluctuations in accordance with current news.

Two influences of opposing character were to be weighed. If the promised submarine campaign were a success our iron and steel exports would be greatly reduced. They were largely to points in the prescribed area, and there was a possibility of exports to South America and Canada being curtailed. In January the export movement involved, directly and indirectly, about 20 per cent of the steel production. An increase of 10 per cent in the domestic supply might have quite an effect.

On the other hand preparations by the United States for war would result in the placing of some rush orders for steel, and the steel producers were all perfectly ready to give such orders all the precedence desired. As it would be the height of inefficiency in such circumstances to fill such orders at the expense of deliveries to those already engaged in fighting the possible enemy of the United States, it would be domestic deliveries that would be delayed in consequence of the new orders.

CURTAILED PRODUCTION

Transportation conditions as affecting the production and shipment of steel were showing signs of slight improvement when a blizzard on Sunday, Feb. 4, swept over the Central West, in a territory producing at least half the country's iron and steel. Instantly railroad traffic was greatly impeded. Car supplies greatly decreased and the dispatch of loaded cars suffered. The chief disturbance, however, was in the Connellsville coke region, coke shipments in the week following the blizzard being probably no more than one-half the requirements of the tributary blast furnaces. Pig iron production in the region affected was already 20 per cent or more below normal and promised to drop to 50 per cent or less. Steel interests which for weeks had been considering themselves fortunate in having reserves of scrap and pig iron to draw upon were confronted with the prospect that these reserves would run out long before transportation conditions became such as to permit normal production of pig iron.

The cold snap froze up the steel mills badly and for a few days production was greatly restricted in some departments from that cause alone. Nearly all natural gas was shut off from the mills still using it, being required for domestic consumers, who by common practice are served first. A tin plate plant in the heart of the West Virginia gas field was closed because the available gas had to be piped to Pittsburgh and elsewhere for domestic consumption.

PIG IRON

Trends noticeable in January have developed farther. There is a more complete absence of interest on the part of consumers in second half deliveries. This is proved conclusively by the existence of an unprecedented condition, that in practically all northern consuming territory southern foundry pig iron is available for second half delivery at prices many dollars a ton below prices the northern furnaces would regard as proper prices in case they were called upon to quote. Their inquiries are confined to early deliveries and early deliveries alone can they sell. To quote lower prices for forward de-

liveries would only embarrass them in making prompt sales. For illustration, the last important sales of valley pig iron for second half delivery, made some time ago, were at \$30, valley, for foundry or basic. Of late the furnaces have been obtaining \$33 to \$35 for small lots of prompt iron, which would be \$33.95 to \$34.95 delivered Pittsburgh, while for second half delivery Southern foundry iron is available at not over \$24, Birmingham, or \$28.55 delivered Pittsburgh. It is available for prompt shipment at the same price, but delivery would be very uncertain on account of the long haul. The normal pig iron market is one for forward deliveries and now there is no such market.

Export pig iron inquiry has diminished greatly. As the heavy export demand had a great deal to do with advancing and maintaining pig iron prices the new international conditions impose even more conservatism upon pig iron buyers than upon steel buyers.

STEEL

About February 1 a sale of 3000 tons of soft, open-hearth billets was made at \$65, f.o.b. maker's mill, Pittsburgh district. Transactions are few and far between and this one is probably representative of the market as far as there is a market.

Finished steel prices are firm all along the line. The advance in shapes and plates of \$3 a ton made by most of the mills in January has become general and prices for delivery at mill convenience may be quoted at 3c. for bars, 3.25c. for shapes and 3.75c. for plates. Large premiums rule on plates for earlier delivery, and small premiums on bars and shapes. Sheets and wire products are steady, with suspicions on the part of buyers that the producers are not sold up as fully as appeared a month ago to be the case. Tin plate is practically unobtainable, with \$8 bid in some instances. The mills are sold very fully to July 1 on tin plate and are altogether indisposed to consider the matter of prices for second half.

Non-Ferrous Metal Market

Feb. 8.—The disturbed international conditions have not caused very great changes at the present writing excepting in tin, which has gone higher in a somewhat excited market. Copper is slightly higher on heavier inquiry and antimony is scarce and higher. Spelter and lead are firm and practically unchanged.

Copper.—Sellers have been extremely shy for the greater part of the last two weeks, and little copper has been offered for early delivery. Electrolytic was offered at 33.50 on Jan. 29, at 33.00 on Feb. 1, and at 34.50 on Feb. 7. Lake has been running about 1 cent under this price. Exports in January were 23,511 tons. On Feb. 7 more inquiry was shown than previously and prices went up.

Tin.—As is to be expected from a market depending on foreign shipping, the tin market is unsettled and no one knows what will happen from one day to the next. There has been considerable activity in Banca tin at prices ranging from 44.50 on Jan. 30 to 51.00 cents on Feb. 7. The New York Metal Exchange gives deliveries for January at 7177 tons, of which 5200 tons were at Atlantic ports and 1977 tons at Pacific ports. This is 1200 tons above the record. Straits is quoted at 55.00 cents.

Lead.—On Jan. 29 the trust price was advanced to 8.00 cents. Independents have been asking from 7½ to 1.00 cent above the trust for some time, and the raise was not unexpected. Lead is scarce and there has been practically no market on spot. At present independents are asking 8.50 to 9.00 cents, prompt delivery.

Spelter.—Ore prices were advanced on Jan. 29, and this was followed by an advance in the metal to 11.05 cents, New York. It was reported on Jan. 31 that Great Britain would not buy any more spelter here, but the report had little effect. Spelter is now quoted at 10.55, New York, for prompt shipment.

Other Metals.—Antimony has become very scarce and has jumped from 23.00 cents on Jan. 29 to 32.00 cents on Feb. 7. Aluminium is now quoted at 57.00 to 59.00 cents, magnesium is down to \$3.00, electrolytic nickel is 50.00 cents, cadmium \$1.50, quicksilver \$100.00, platinum \$100.00, cobalt \$1.50, and silver 77%.

Chemical Market

Should the diplomatic break with Germany eventuate into open hostilities the chemical markets, particularly the coal tar division, will of course attract national attention. At the moment of writing sufficient time has not elapsed to effect material changes. Sellers, however, have adopted a very cautious attitude and the general tendency is to hold off pending developments.

Benzol has been subjected to considerable activity during the interval and the general asking rate of sellers has been on a higher level than when we last reported. One producer has been a disturbing influence, however, and some of their output was offered at a price considerably under the general market. However, only the most favored buyers could secure this material and it is believed that most of this product has now been sold. The largest selling interest has been accepting contracts over the three-year period with a guarantee against declines. It is estimated that the production of benzol at the present time is approximately 40,000,000 gal. yearly.

The *toluol* situation has become very interesting. In view of the probability of the American government shortly coming into the market for supplies of T. N. T. the general tendency is to hold supplies and there is a pronounced speculative interest present that is attempting to secure such supplies that may be available at attractive prices.

Again with *phenol*, the possibility of large orders for picric acid developing has once more created a firmer feeling in this market after a pronounced weak tendency for the past two weeks. Offerings from the middle West had resulted in the lowest prices that have prevailed for a long time and in consequence Eastern producers were compelled to meet this competition.

Aniline oil, however, has maintained an unusual degree of firmness during the interval and this situation was not in any way a reflection of political conditions. There are approximately 45 plants equipped with apparatus for the manufacture of aniline oil or its homologues in this country and the actual producers at the moment do not probably exceed 15. This is due to the unusually low prices that have been prevailing of late making it possible for only the most favorably situated from the raw material viewpoint to manufacture profitably. The production has decreased largely and a large number of export orders have reached this market of late resulting in an advance of more than 5 cents per lb. during the fortnight.

Ortho and *para toluidine* have become scarce with prices high as a result of the restricted production and the difficulty of separation. *Toluidine* mixture has been made in a fair way but unseparated has found but limited markets. A production of *toluidine* is announced by a prominent company, which has heretofore principally confined its operations to *alpha-naphthylamine*. Commercial *toluidine* base is held at \$3 for prompt delivery with producers not open for contracts at this time.

H acid (the amidonaphthol disulphonic acid 1:8:3:6) continues to attract a vast amount of attention. There is but little doubt that with the endless discussion of this product there will be a number of producers within the year. Already a production is announced for the near future by two entirely new factors who have not heretofore figured in this field.

Heavy Chemicals.—The possibility of restricted exports has generally tended to lower prices in this department of the industry. Products such as *copper sulphate*, which depend to a large degree on the export trade for their stability, slumped rather sharply. Weakness still prevails and general conditions are unsettled.

Caustic soda and *soda ash* have been working rather well in unison. The break with Germany resulted in a sharp decline in the former product but during the intervening few days there has been some quiet important buying and the general tendency at the moment of writing is to a recovery of lost values.

Glycerine has naturally been subject to much attention as a result of the international situation and an advance of several points has already been scored. The situation in this product is always more or less under stable control and a firmer market is likely. *Formaldehyde* has been scarce and considerable business has passed for domestic and export account.

Owing to the more liberal offerings of *cyanides* from abroad the situation has eased off considerably. The domestic situation is tight but as most material offered of late has been in speculative hands these interests have weakened in the face of liberal foreign offers principally from Japan.

In pharmaceuticals, *citric acid* and *citrates* have advanced sharply in face of the probability of more than an usual brisk spring demand. *Mercury* and *mercurials* have also advanced as has *cream of tartar*.

Interesting developments are expected in the market during the next few weeks and to-day's prices have but little meaning or value to-morrow. The crisis that has developed finds the chemical trade generally in better shape to assist the national government than ever before and already a number of the leading chemical manufacturers have offered the facilities of their plants to Washington.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET FEBRUARY 7, 1917

Acetone, Drums	lb.	23	..23 1/2
Acid, acetic, 28 per cent.	100 lb.	3.25	..3.50
Acetic, 56 per cent.	100 lb.	6.75	..7.00
Acetic, glacial, 99 1/2 per cent, carboys	lb.	22	..23
Boric, crystals	lb.	11 1/2	..11 3/4
Citric, crystals	lb.	72	..80
Hydrochloric, commercial, 18 deg.	lb.	0.11 1/2	..0.11 1/2
Hydrochloric, 20 deg.	lb.	0.11 1/2	..0.11 1/2
Hydrofluoric, C. P., conc., 22 deg.	lb.	0.11 1/2	..0.11 1/2
Hydrofluoric, 20 per cent, in barrels	lb.	0.11 1/2	..0.11 1/2
Lactic, 44 per cent.	lb.	11 1/2	..12
Lactic, 22 per cent.	lb.	0.11 1/2	..0.11 1/2
Nitric, 36 deg.	lb.	0.11 1/2	..0.11 1/2
Nitric, 42 deg.	lb.	0.11 1/2	..0.11 1/2
Oxalic, crystals	lb.	46	..48
Phosphoric, 85 per cent.	lb.	30	..32
Picric	lb.	70	..75
Pyrosulphic, resublimed	lb.	3.25	..3.50
Sulphuric, 66 deg., Brimstone	ton	21.00	..25.00
Sulphuric, 60 deg., Brimstone	ton	20.00	..21.00
Sulphuric, oleum (Fuming), tank cars.	ton	34.00	..35.00
Tannic, tech.	lb.	45	..50
Tartaric, crystals	lb.	72	..85
Alcohol, grain, 158 proof.	gal.	2.72	..2.74
Alcohol, Wood, 95 per cent.	gal.	1.00	..1.02
Alcohol, Denatured, 180 proof.	gal.	67	..67
Alum, ammonium lump.	lb.	0.14 1/2	..0.14 1/2
Alum, chrome (ammonium)	lb.	21	..23
Alum, chrome (potassium)	lb.	30	..34
Alum, potash lump.	lb.	0.14 1/2	..0.14 1/2
Aluminum Sulphate, technical.	lb.	0.17 1/2	..0.17 1/2
Aluminum Sulphate, iron free.	lb.	0.03	..0.03 1/4
Ammonia aqua, 26 deg., carboys	lb.	0.05 1/2	..0.06
Ammonia anhydrous	lb.	12 1/2	..13
Ammonium carbonate	lb.	14	..14 1/2
Ammonium nitrate	lb.	0.04	..0.04 1/4
Ammonium sulphate, domestic	lb.	4.00	..4.25
Amyl acetate	gal.	1.0 1/2	..1.1
Arsenic, white	lb.	25	..30
Arsenic, red	lb.	92.00	..95.00
Barium chloride	ton		

Barium sulphate (Blanc Fixe) powder.....lb.	.04½	.04½
Barium nitrate.....lb.	.12	.12½
Barium peroxide, basis 70 per cent.....lb.	.28	.30
Bleaching powder, 35 per cent (large drums).....lb.	.03½	.04½
Borax, crystals, sacks.....ton	28.50	29.00
Brimstone, crude.....ton	1.30	1.35
Bromine, technical.....lb.	.03½	.03½
Calcium acetate, crude.....ton	55.00	90.00
Calcium carbide.....ton	55.00	90.00
Calcium chloride, 70-75 per cent, fused, lump.....ton	23.50	25.00
Calcium peroxide.....lb.	1.70	1.75
Calcium sulphate.....lb.	.01	.01½
Calcium phosphate.....lb.	.08	.10
Carbon bisulphide.....lb.	.04½	.04½
Carbon tetrachloride, drums.....lb.	.15½	.16
Caustic potash, 82-92 per cent.....lb.	.85	.88
Caustic soda, 75 per cent.....lb.	.40	.41½
Chlorine, liquid.....lb.	.15	.16
Copperas.....100 lb.	1.15	1.25
Copper carbonate.....lb.	.37	.39
Copper cyanide.....lb.	.70	.75
Copper sulphate, 99 per cent, large crystals.....lb.	.10	.11
Cream of tartar, crystals.....lb.	.42	.42½
Epsom salt bags.....100 lb.	.01½	.02
Ferrihydride, 40 per cent.....lb.	.45½	.47½
Glauber's salt.....100 lb.	.65	.70
Glycerine, bulk, C. P.....lb.	.54½	.55
Iodine, resublimed.....lb.	3.50	3.55
Iron oxide.....lb.	.02	.08
Lead acetate, white crystals.....lb.	13.3½	14½
Lead arsenate.....lb.	.09	.09½
Lead nitrate.....lb.	16½	16½
Litharge, American.....lb.	.08	.09
Lithium carbonate.....lb.	1.03	1.03
Manganese dioxide.....lb.	.65	.70
Magnesium carbonate, tech.....lb.	.13	13½
Nickel salt, single.....lb.	.14	.14
Nickel salt, double.....lb.	.14	.14
Phosphorus, red.....lb.	1.08	1.15
Phosphorus, yellow.....lb.	.60	.65
Potassium bichromate.....lb.	37½	.38
Potassium bromide, granular.....lb.	1.20	1.25
Potassium carbonate, calcined, 80-85 per cent.....lb.	.30	.32
Potassium chlorate, crystals.....lb.	.64	.65
Potassium cyanide, 98-99 per cent.....lb.	2.40	2.40
Potassium iodide.....lb.	2.90	2.92
Potassium muriate, 80-85 per cent basis of 80 per cent.....ton	100.00	125.00
Potassium nitrate.....lb.	.30	.32
Potassium permanganate.....lb.	3.75	4.00
Potassium prussiate, red.....lb.	2.50	2.75
Potassium prussiate, yellow.....lb.	.90	.92
Potassium sulphate, 90-95 p.c. basis 90 p.c. ton	300.00	325.00
Rochelle salts.....lb.	.24	.24½
Sal ammoniac, gray gran.....lb.	.09	.09½
Sal ammoniac, white gran.....lb.	.17	17½
Sal soda.....100 lb.	1.10	1.15
Salt cake.....100 lb.	1.40	.75
Silver cyanide, based on silver market.....oz.	.72	.75
Silver nitrate.....oz.	47½	49½
Soda ash, 58 per cent, light, flat.....100 lb.	2.75	2.85
Soda ash, 58 per cent, dense, flat.....100 lb.	2.75	2.85
Sodium acetate.....lb.	.08	.08½
Sodium benzoate.....lb.	7.50	8.00
Sodium bicarbonate, domestic.....100 lb.	1.80	2.00
Sodium bicarbonate, English.....lb.	.45	.05½
Sodium bichromate.....lb.	.15	.15½
Sodium bisulphite, powd.....lb.	.04½	.05
Sodium chlorate.....lb.	.25	.26
Sodium cyanide.....lb.	1.25	1.30
Sodium fluoride, commercial.....lb.	.12	.12
Sodium hyposulphite.....lb.	.01½	.01½
Sodium nitrate, refined.....100 lb.	3.40	3.45
Sodium nitrate, crude.....lb.	1.5½	1½
Sodium peroxide.....lb.	.90	1.10
Sodium phosphate (tri.).....lb.	.04½	.05
Sodium prussiate, yellow.....lb.	.33	.34
Sodium silicate, liquid, 40-55 deg.....100 lb.	1.50	1.60
Sodium sulphide, 30 per cent crystals.....lb.	.02	.03½
Strontium nitrate.....lb.	.30	.32
Sulphur chloride, drums.....lb.	.09½	.10
Sulphur dioxide, cylinders.....lb.	11½	12
Sulphur, flowers, sublimed.....100 lb.	1.15	1.20
Sulphur, roll.....100 lb.	1.90	2.00
Sulphur, crude.....ton	36.00	38.00
Tin bichloride, 50 deg.....lb.	14	14½
Tin oxide.....lb.	.45	.49
Zinc carbonate.....lb.	.26	.27
Zinc chloride.....lb.	.13	13½
Zinc cyanide.....lb.	.50	.51
Zinc dust.....lb.	.30	.24
Zinc oxide, American process XX.....lb.	11½	11½
Zinc sulphate.....lb.	.06	.06½

Coal Tar Products (Crude)

Benzol, pure, water white.....gal.	.55	.57
Benzol, 80 per cent.....lb.	.55	.58
Chlorol, pure, water white.....lb.	1.20	1.20
Xylo, pure, water white.....lb.	1.00	1.00
Solvent naphtha, water white.....gal.	.21	.22
Solvent naphtha, crude heavy.....gal.	13	15
Cresosote oil, 25 per cent.....gal.	.25	.26
Dip oil, 20 per cent.....gal.	.22	.24
Pitch, various grades.....ton	7.50	20.00
Carbolic acid, crude, 95-97 per cent.....lb.	.85	.95
Carbolic acid, crude, 50 per cent.....lb.	.60	.65
Carbolic acid, crude, 25 per cent.....lb.	.25	.27
Cresol U. S. P.....lb.	.18	.22

Intermediates, Etc.

Alpha naphthylamine.....lb.	1.00	1.25
Aniline oil.....lb.	.25	.28
Aniline salts.....lb.	.27	.30
Anthracene, 80 per cent.....lb.	104	104
Benzaldehyde.....lb.	1.25	4.50
Benzidine, base.....lb.	1.60	1.75

Benzoic acid.....lb.	8.50	9.00
Beta naphthol, sublimed.....lb.	.85	.90
Dichlor benzol.....lb.	.48	.55
Dimethylaniline.....lb.	.55	.60
Diphenylamine.....lb.	.80	4.75
H-ol.....lb.	Nominal at 2.50	
Metaphenylenediamine.....lb.	1.60	1.75
Monochlorbenzol.....lb.	.32	.33
Naphthalene, flake.....lb.	1.09	1.10
Naphthionic acid, crude.....lb.	1.50	2.00
Ortho-aminophenol.....lb.	1.25	1.50
Ortho-toluidine.....lb.	1.25	1.50
Para-aminophenol, base.....lb.	4.25	4.50
Para-aminophenol, sulphate.....lb.	4.50	4.75
Para-aminophenol, hydrochloride.....lb.	5.50	6.00
Paranitraniline.....lb.	1.35	1.45
Paraphenylenediamine.....lb.	3.50	3.75
Para-toluidine.....lb.	1.50	1.75
Phenol, U. S. P.....lb.	.47	.50
Resorcin, technical.....lb.	9.00	17.00
Resorcin, pure.....lb.	16.50	17.00
Sulphuric acid.....lb.	1.50	1.55
Sulphanilic acid.....lb.	.35	.36
Toluidine, base.....lb.	3.00	
Toluidine mixture.....lb.	.65	.90

Petroleum Oils

CRUDE (AT THE WELLS)

Pennsylvania.....bbl.	3.05	—
Corning, Ohio.....bbl.	2.38	—
Summers, Ky.....bbl.	2.38	—
Wooster, Ohio.....bbl.	2.05	—
Indiana.....bbl.	1.73	—
Illinois.....bbl.	1.90	—
Oldiana and Kansas, except Healdton.....bbl.	1.85	—
Healdton, 32 deg. and above.....bbl.	.90	—
Caddo, La., light.....bbl.	1.70	—
Corsicana, Tex., light.....bbl.	1.70	—
California.....bbl.	.73	.82

LUBRICANTS

Black, reduced, 29 gravity, 25-30 cold test.....gal.	13½	14
Cylinder, light.....gal.	.21	.26
Cylinder, dark.....gal.	.18	.19
Extra cold test.....gal.	2.45	2.45
Paraffine, high viscosity.....gal.	29½	30
Paraffine, 0.903 spec. gr.....gal.	21½	22
Paraffine, 0.865 spec. gr.....gal.	18½	19

Flotation Oils

Pine oil, steam distilled.....gal.	.59	—
Pine oil, destructively distilled.....gal.	.47	—
Pine-tar oil.....gal.	.19	—
Pine-tar oil, double refined.....gal.	.30	—
Pine oil, light.....gal.	.37	—
Pine oil, heavy.....gal.	.26	—
Pine tar, thin.....gal.	.38	—
Turpentine, crude.....gal.	.38	—
Hardwood oil, f.o.b. Michigan.....gal.	.16	—
Cresosote, coal tar, neutral.....gal.	.15	—
Cresosote, coal tar, acid.....gal.	.21	—
Coal tar, thin.....gal.	.12	—

Vegetable and Other Oils

China wood oil.....gal.	13½	—
Cottonseed oil, crude.....gal.	.80	.82
Linseed oil, raw, cars.....gal.	.94	—
Peanut oil, crude.....gal.	.88	.90
Rosin, 280 lb.....bbl.	6.30	—
Rosin oil, first run, f.o.b. China.....gal.	7.50	—
Rosin oil, fourth run.....gal.	.78	—
Soya bean oil, Manchuria.....gal.	.12	—
Sperm oil, bleached winter, 38 deg.....gal.	.12	12½
Turpentine, spirits.....gal.	.52½	—

Miscellaneous Materials

Barytes, roasted, white, domestic.....ton	25.00	35.00
Beeswax, white pure.....lb.	.48	.50
Carnauba wax, highest grade.....lb.	.50	.51
Chalk, light, precipitated, English.....lb.	.03	.06
Feldspar.....ton	8.00	12.00
Fulur's earth, powdered.....lb.	1.80	1.05
Red lead, dry, carloads.....lb.	.09½	—
Soapstone.....ton	10.00	12.50
Talc, American, white.....ton	10.00	13.00
White lead, dry.....lb.	.08½	—

Refractories, Etc.

(F.O.R. WORKS)

Chrome brick.....net ton	120.00	130.00
Chrome cement, Grecian.....net ton	80.00	90.00
Clay brick, first quality fireclay.....per 1000	40.00	50.00
Magnesite, Grecian, dead burned.....net ton	85.00	90.00
Magnesia brick, Grecian, 9x14x3½.....net ton	135.00	140.00
Silica brick.....per 1000	40.00	45.00

Ferroalloys

Ferro-carbon-titanium, carloads.....lb.	.08	—
Ferrochromium, carloads.....lb.	.19	—
Ferromanganese, domestic, delivered, contract.....ton	165.00	—
Ferromanganese, English, contract.....ton	175.00	—
Ferromolybdenum.....lb.	4.00	—
Ferrosilicon, 50 p.c., carloads, del. Pittsburgh.....ton	140.00	200.00
Ferrosilicon, 50 p.c., contract, del. Pittsburgh.....ton	100.00	—
Ferrotungsten, 75-85 p.c., f.o.b. Pittsburgh.....lb.	2.10	2.15
Ferrovanadium, f.o.b. works.....lb.	2.75	3.00

INDUSTRIAL

Financial, Construction and Manufacturers' News

Financial

Atlas Refining Company, Delaware, has been incorporated with a capital of \$150,000 to produce petroleum and its products. The incorporators are C. W. Kirkland, Muskogee, Okla.; P. W. Murray, Bridgeport, Conn.; J. P. Given, New York; E. Walter Mitchell, Brooklyn, and Count Thomas Devassay, Budapest, Austria-Hungary.

The Auto Products Company, Nashville, Tenn., has been incorporated with a capital of \$2,000. Incorporators are A. E. Potter, A. Odell, F. M. Kelly, J. C. Ransom, P. C. Bowers, S. C. Ewing, F. H. Turner, H. C. Tucker and W. H. Ewing. The company expects to make benzoic acid and other chemicals.

Canton Metal Products Company, Canton, Ohio, has been incorporated with a capital of \$1,000,000. Incorporated by H. G. Bow.

The Carbonate Copper Company, San Antonio, Tex., has been incorporated with a capital of \$10,000. The incorporators are E. L. Porch, W. Schertz and W. F. Miller.

The Carlo-Nitrate Company, Pittsburgh, Pa., has increased its capital from \$5,000,000 to \$7,500,000.

The Cincinnati Iron and Steel Company has increased its capital stock from \$400,000 to \$800,000.

The Clover Foundry Company, Muskegon, Mich., has been incorporated with \$50,000.

Coeur-d'Alene Copper Mining Company, Spokane, Wash., has been incorporated with a capital of \$25,000. The incorporators are E. A. Laing, L. Harvey, M. A. Schneider, Comstedt & Company, Inc., New York.

Comstedt & Company, Inc., New York, has been incorporated with a capital of \$100,000. The incorporators are G. L. R. Munson, H. Waddington, J. T. A. Comstedt, 120 Broadway. The company is authorized to conduct business in iron, steel, and metal work.

Copper Products Company, Augusta, Me., has been incorporated with a capital of \$250,000 to carry on a general business of foundry, machine shop, manufacturing, depositing metals on other metals, and other business. The incorporators are S. S. Stevens, Manchester, Mass.; H. P. Sweetser, Portland, E. C. Ramsdell, Boston; P. E. Coyle, A. P. Brewer, Portland.

Driggs Mfg. Corp., New York, has been incorporated with a capital of \$300,000 to engage in factory supplies, ammunition, explosives, marine craft, aeroplanes. The incorporators are W. Zane, W. Abramson, L. L. Driggs, Jr., 120 Broadway.

The Durham Iron Works, Inc., Durham, Va., has been incorporated with a capital of \$25,000 for general foundry and machine shops. The incorporators are W. R. Kreker, W. F. Muellerhoeen, and others.

The E. I. du Pont de Nemours Powder Company is said to have offered \$1,000,000 for the plants and business of Harrison Bros. & Company, Inc., The Harrison Bros. Company has large plants at Philadelphia and Paulsboro, N. J., and manufactures paints, pigments, and chemicals. It is also the owner of pyrite mines in Virginia. Russell S. Hubbard is president and general manager of the Harrison Bros. Company.

Eastern Chemical Company, Wilmington, Del., has been incorporated with a capital of \$200,000.

The Electric Chemical Company, Salisbury, N. C., has been incorporated with a capital of \$10,000. The incorporators are M. A. Hodgkin, C. L. Jurkley, and others.

M. M. Elish & Company, Inc., Manhattan, has been incorporated with a capital of \$25,000 to manufacture paper. The incorporators are M. M. Elish, 620 E. 26th Street, Brooklyn; L. H. Biglow, Jr., South Orange, N. J.; H. L. Gutterson, Beechmont Park, New Rochelle.

The Excelsior Chemical Company, Youngstown, Ohio, has been incorporated with a capital of \$15,000. The incorporators are J. W. Blackburn, J. P. Wilson, C. W. Osborne, F. J. Heim, R. B. Wilson.

J. B. Gathright Land Company, Louisville, Ky., has been incorporated with a capital of \$25,000 to deal in oil, gas and other mineral properties. Incorporators,

W. H. Field, Matt O'Doherty, J. S. Clark, H. Harrison.

The General Chemical Company doubled its net profits in 1916. The amount for the year ending Dec. 31, 1916, was \$12,481,826, compared with \$6,153,796 for the year ending Dec. 31, 1915.

Great American Refining Company, Indianapolis, Ind., has been incorporated in Delaware with a capital of \$10,000,000 to produce oil and its products. The incorporators are Jos. O. More, Orpheus L. Teague, L. E. Replige, all of Indianapolis.

Grasselli Chemical Company earnings were reported at \$9,935,000 for 1916, or slightly better than 70 per cent of the present common stock issue of \$13,913,000, after deducting the preferred stock dividend requirements. In 1915 the company earned \$4,859,000.

The Harley Company, Springfield, Mass., has been incorporated to manufacture machinery and tools with a capital of \$1,200,000. The incorporators are L. J. Harley, L. J. Harley, Jr., Chas. H. Beckwith, all of Springfield.

Holland Aniline Dye Company, Holland, Mich., has been incorporated with a capital of \$100,000. The \$200,000 stock recently placed on the market has been subscribed.

The Hollander Manufacturing Company, Cleveland, Ohio, has been incorporated with a capital of \$10,000 to deal in metal products. The incorporators are J. Hollander, L. Hollander, H. Schanberg, J. Holstein and J. Hudik.

Industrial Paint Works, Inc., Passaic, N. J., has been incorporated with a capital of \$100,000 to manufacture paints and painters' supplies. The incorporators are R. Huff, J. P. Salisbury, F. A. Katterson.

International Peroxide Company, Brooklyn, N. Y., has been incorporated with a capital of \$100,000 to deal in and manufacture chemicals. Incorporators, J. R. Levine, I. Heitler, W. Wisch, 45 Malta Street, Brooklyn.

The Iola Portland Cement Company, Iola, Kan., has been purchased by the Iola Portland Cement Company, a Pennsylvania corporation operating cement plants in Pennsylvania, Virginia, Indiana, Washington, Illinois and Mason City, Ia.

The new owners will continue the policy of increasing the efficiency of the Iola plant. The Iola Portland Cement Company, a 23, million concern with general offices in the Commerce Building, Kansas City, expended \$300,000 in modernizing the plant last year and a similar outlay is to be made this year.

H. Struckmann, J. J. Helm, R. A. Long, J. W. Perry and A. D. Bayles are among the Kansas City stockholders of the Iola Company. The largest stockholder has been the National Bank of Commerce of St. Louis.

The Iowa Pure Iron Company, De Moines, Iowa, has been incorporated with a capital of \$300,000 to deal and manufacture sheet iron metal products. Incorporators are H. L. Helsing, E. Bern, A. G. Helsing.

Kennecott-Barrett Copper Company, Seattle, Wash., has been incorporated with a capital of \$1,500,000. The incorporators are Geo. Meier, T. C. Brownlee, W. A. Gaines and Geo. A. Lee.

Kennecott Extension Copper Company, Wilmington, Del., has been incorporated with a capital of \$5,000,000 to prepare all kinds of metals and minerals for market. The incorporators are M. B. Rogers, L. A. Irwin, H. W. Davis, all of Wilmington.

Keystone Mfg. Company, New Kensington, Pa., has been incorporated with a capital of \$30,000 to manufacture various articles of iron, steel, etc. The incorporators are J. P. Posahon, M. G. Penney, C. J. Lange.

Lukens Steel Company, Coatesville, Pa., has been incorporated with a capital of \$10,000. Gustave T. Schnatz, Philadelphia, treasurer.

Mechanical Window Glass Company, Springdale, Pa., has been incorporated with a capital of \$5,000,000 to manufacture window plate glass. The incorporators are Geo. G. Debay, Springdale; Warren D.

Gump; Arnold, Pa., and H. L. Schenck, of Pittsburgh.

Michel-Bilodeau Chemical Company, San Francisco, Calif., has been incorporated with a capital of \$50,000 to deal in drugs, chemicals and toilet articles. The incorporators are H. Michel, L. Bilodeau, F. B. Canas-Marquis.

The National Chemical Company, Ltd., with offices in the People's Gas Bldg., Chicago, has recently been incorporated for \$1,250,000 in S. Dakota and Illinois. The company will manufacture potash and by-products from kelp. An exclusive concession by the Canadian Government on kelp beds at Pafco, Queen Charlotte Island, B. C., which are estimated to produce 1,000,000 tons of kelp annually. The company's holdings are also in an excellent fishing district and it is expected to make the returns from fish fertilizer an important part of the company's income. Mr. M. V. Coone is president and general manager; Mr. Geo. A. Schwabland, who has had much experience in the kelp industry, is the company's chemical engineer.

New Jersey Dyestuffs Corp., Jersey City, N. J., has been incorporated with a capital of \$25,000 to deal in dyestuffs and chemicals of all kinds. The incorporators are J. Schneider, N. Marcus, R. Rieser, of Hoboken.

Nicholson Furnace Mfg. Company has been incorporated in Delaware with a capital of \$200,000 to manufacture furnaces, stoves, etc. The incorporators are J. Fry, L. T. Hopkins, and George H. Harman, all of New York.

Nome Sunset Mines, Inc., Nome, Alaska, has been incorporated in Delaware with a capital of \$2,500,000 to engage in mining of all kinds. The incorporators are J. Tobin, A. F. McIntosh, Jas. Halpin.

The North & South American Oil Company, Wilmington, Del., has been incorporated with a capital of \$500,000 to deal in oil lands and mining properties.

Old Dominion Chemical Company, Inc., Yorktown, Va., has been incorporated with a capital of \$275,000 to manufacture chemicals. The incorporators are E. H. Christian and E. S. Bolen, both of Richmond.

The Penant Produce Company, Cleveland, Ohio, has been incorporated with a capital of \$1,000,000 to manufacture and sell metal products of all kinds. Incorporators are B. D. Stevenson, G. R. Stevenson, L. B. Foote, W. A. Thompson, A. J. Hudson, all of Cleveland.

Pole Star Copper Company, Salt Lake City, Utah, has been incorporated with a capital of \$1,500,000. The business of the company will be mining, milling, smelting, etc. The incorporators are H. E. Latter, N. P. Coffin and H. T. Farrow.

Renania Chemical Works, Inc., New York, has been incorporated with a capital of \$15,000 to manufacture and deal in chemicals and medicines. The incorporators are J. H. Hutton, G. A. Wortelman, J. V. Bendish, 17 South Street.

The Reward Chemical Company, Toledo, Ohio, has been incorporated with a capital of \$10,000. The incorporators are J. L. Greenbaum, A. A. Greenbaum, Christ. Hopp, L. J. Mechler, and Sadie N. Joyce.

Roseburgh Chemical Corp., Syracuse, N. Y., has been incorporated with a capital of \$50,000 to manufacture chemicals. The incorporators are J. E. Porter, T. Hiseock, R. M. Roseburgh.

Royal Dye Works, Inc., New York, has been incorporated with a capital of \$10,000 to deal in dyes and chemicals. The incorporators are E. P. Kamholz, L. Scorsone, W. Koenig, 25 Echo Road, New Rochelle.

Serenita Mining Company has been incorporated in Delaware with a capital of \$30,000 to explore for and mine minerals, etc. The incorporators are V. C. Rogardus, H. H. Walter, M. Friedberg, all of New York.

Shure White Chemical Company, Mayfield, Ky., has been incorporated with a capital of \$5,000 to manufacture chemicals. The incorporators are L. Evans, W. W. Evans and N. E. Thomas.

Stockholders of the Solvay Process Company will vote on Feb. 27 to increase the capital stock from \$10,000,000 to \$20,000,000. Of the increase \$2,000,000 is to be offered to the share owners for subscription on the basis of 20 per cent of their holdings, as of March 1.

Springfield Wall Paper & Paint Company, Springfield, Mass., has been incorporated with a capital of \$10,000. The incorporators are J. Howard Jones, Geo. W. Steele and W. H. McCarthy.

The Standard Gas Power Company, 17 Battery Place, New York, is undergoing

a reorganization which will take several months. Mr. Akerlund, formerly chief engineer, has formed a company to be known as Akerlund & Semmes, 17 Battery Place, New York, to carry on combustion engineering business. It is possible that this company may be included in the reorganization of the Standard Gas Power Company.

Standard Oil Gas Burner Company, Wilmington, Del., has been incorporated with a capital of \$30,000 for manufacture and sale of oil gas burners.

Steffanson & Company, Inc., New York, has been incorporated with a capital of \$100,000 to manufacture paper. Incorporators, C. Engel, R. N. Chambers, J. French, 59 Wall Street.

The Stockholders Mining Company, Portland, Me., has been incorporated with a capital of \$2,000,000 to engage in mining, quarrying, smelting, refining, copper, gold, silver and all kinds of ores, etc.

B. T. Tuttle and W. W. Gregory, of Roscoe, N. Y., have formed a partnership for the manufacture of dyes. A factory will be erected in the spring.

The Union Oil Company, of California, in its financial report for the year ending Dec. 31, 1916, shows the company to have had a most successful year. Net profits are given as \$7,200,000, or \$4,380,000 greater than 1915.

United Chemical Company, Pittsburgh, Pa., has been incorporated with a capital of \$5,000. Incorporator, Jas. D. White.

United States Chemical Company, New Haven, Conn., has been incorporated with a capital of \$50,000, to manufacture and deal in chemicals. The incorporators are J. H. Sheehan, D. M. Freeman, J. J. Dunlap, all of New Haven.

Utah Mineral Paint Company, Salt Lake City, Utah, has been incorporated with a capital of \$50,000. The incorporators are C. H. Barton, David Jensen and Geo. A. Barry. Headquarters will be in Ogden.

The Val Blatz Paint & Varnish Company, Louisville, Ky., has changed its name to the Blatz Company. It has increased its capital from \$10,000 to \$30,000.

Virginia-Tennessee Iron Corp., Clifton Forge, Va., has been incorporated with a capital of \$100,000. Incorporators, C. F. Sente, A. C. Ford, of Clifton Forge.

Wade Process Corp., New York, N. Y., has been incorporated with a capital of \$300,000 to deal in oils and greases. The incorporators are L. Vinton, C. Mason, J. M. Keating, 30 Church Street.

The West Texas Sulphur Company, a Delaware corporation, has been granted a permit to do business in Texas. The company has \$500,000 capital stock and has headquarters in Philadelphia. Texas headquarters are in Texas.

Williams & Ferguson, Inc., Terre Haute, Ind., has been incorporated with a capital of \$15,000 to manufacture and sell wall paper, glass and oils and other articles. The incorporators are J. R. Ferguson, John Williams, Chas. F. Williams.

Worth Steel Co., Wilmington, Del., has been incorporated with a capital of \$2,500,000 to manufacture and deal in iron, steel, manganese, etc. The incorporators are J. E. Worth, W. P. Worth, E. H. Worth, W. A. Worth, N. T. Entrekin, all of Coatesville, Pa.

Construction and Operation

Arizona

CASA GRANDE.—Plans are being prepared for erecting concentrating plant at Lake Shore mine south of Casa Grande. E. P. Ryan, Mgr.

Arkansas

FLIPPIN.—The Marion County Zinc Company began operation on its new concentrating plant, having a capacity of 200 tons a day.

California

BERKELEY.—The Macauley Foundry Company will enlarge its plant on land recently purchased. The San Francisco Concentrating Company will use a new half block recently purchased for storage purposes until work on the new factory is begun.

BERKELEY.—The Paraffine Paint Company will erect a million dollar linoleum factory, the first of its kind in the West. The factory will be devoted to the manufacture of linoleum. The cost will be \$250,000.

LOS ANGELES.—The American Trona Company has plans calling for the immedi-

ate expenditure of \$300,000. The large factory will be completed. A decision was recently handed down by Judge H. T. DeWahl in the Superior Court of San Bernardino County favorable to the corporation in a suit brought by Harry E. Lee and others. The decision gives clear title to 25,000 acres in San Bernardino County. The company will go ahead immediately with the completion of its huge potash refining plant at the harbor.

SACRAMENTO.—Plans for building a big mill on the Pacific Coast to convert sawdust into cellulose are being completed.

SONORA.—The Dutch-App Mines Company is planning the erection of a new milling plant at the App mine. In connection with the mill in operation at the Dutch mine, the plant will be among the largest in California. It is probable the flotation process will be employed to a large extent, and the Dutch embody this method recently installed at the Dutch mine has proved satisfactory.

STELTON.—The Warman Steel Castings Company of Redondo Beach will build a country here. The company has operated an electric furnace at Redondo since 1913.

Connecticut

BRIDGEPORT.—The Hamilton & De Loss Company will have its new factory ready by June 1, 1917, for the manufacture of metal stamps and presses. The company was recently formed, with \$100,000 capital, and has the following officers: H. H. Hamilton, president; W. E. Cutler, superintendent, and R. L. Leach, chief chemist and metallurgist.

Illinois

CHICAGO.—The Reider Foundry Company has purchased land at the southeast corner of Oakley Avenue and 35th Place and will erect a foundry, to cost \$30,000.

CHICAGO.—The Iroquois Iron Company will erect a new steel casting plant which will cost more than one million dollars. Work will be started at once and will be pushed to completion by the end of the year. The plant will have a capacity of about 50,000 tons a day and it will increase the company's output to 1300 tons daily. The plant will be located at South Chicago, at the mouth of the Calumet River.

VANDALIA.—The Ford Manufacturing Co., manufacturers of roofing materials and compounds, will build a new lathe plant, paper mill and power plant.

Iowa

GILMORE CITY.—Work on the 1000-barrel plant of the Fort Dodge Portland Cement Co. is approaching completion, and if no further serious delays are met in the receiving of supplies this plant will be manufacturing cement by the middle of the year. Mr. H. C. Lehigh, formerly chief chemist for the Lehigh P. C. Company at Mason City, is to be superintendent of this new mill.

MASON CITY.—Construction on the new 1,500,000-dollar beet sugar plant of the Northern Sugar Corporation is being pushed as rapidly as possible, though some delay is experienced in getting the structural steel.

Kentucky

JEFFERSONVILLE.—The Armour Fertilizer Company expects to start work on erecting a plant in the near future.

MIDDLEBORO.—A co-operative paper mill was proposed at a meeting of representative publishers from southeastern Kentucky and eastern Tennessee on Jan. 20.

Maryland

BALTIMORE.—The American Refractories Company, Joliet, Ill., will erect a plant here, to cost \$100,000.

BALTIMORE.—The Canton Company is planning the erection of a \$75,000 factory at Highlandtown for the Electrotype Zinc Company.

BALTIMORE.—Electrolytic Zinc Company, 16th St. and 2d Ave., with plant at Highlandtown, plans erecting \$75,000 plant in the same section.

BALTIMORE.—The Davison Chemical Company is contemplating erecting a large Machine shop that will cost \$100,000.

Massachusetts

NEW BEDFORD.—The Taunton-New Bedford Copper Company will rebuild plant recently destroyed by fire, with loss of \$275,000.

Michigan

MANISTEE.—Work on the new plant of the Fer Fildes Company, a \$300,000 concern, is advancing rapidly and is expected to be completed in three months.

REED CITY.—The Ex-Cel-O-Paint Company, capitalized at \$100,000, will begin active manufacturing operations in a short time at Marion. A new plant will be built.

Missouri

POPULAR BLUFF.—The Butler Iron Company, recently incorporated, will erect blast furnace, concentrating plant and chemical plant to cost about \$650,000. W. W. Meehling, pres., Rookery Bldg., Chicago, Ill.

ST. LOUIS.—The Missouri Plate Glass Company, with a capital of one and one-half millions, with the Valley Park Realty Company capitalized at half a million, have recently been incorporated and will undertake the manufacture of glass in Valley Park.

Montana

BUTTE.—A number of capitalists have prepared plans to build a paper pulp mill near Big Fork, in Montana. The paper pulp will be made from the Montana spruce, which abounds in the Flathead country. The incorporators of the new company are J. F. Jordan of the Partridge Company, Warner of the McGill-Warner Company of St. Paul; G. M. and L. S. Gillette of the Minneapolis Steel and Foundry Company; J. F. Jordan of the Partridge Company, Minneapolis, and W. P. Snow, of Big Fork, Mont.

Nebraska

ALLIANCE.—The Black Hills Mica Company has planned the erection of a mica refining plant here. The plant will be for splitting and grinding mica as obtained from the mines.

New Jersey

RAYONNE.—The Texas Company has taken over a large tract of land in Bayonne, fronting on Newark Bay, for a refinery.

LINDEN.—The American Cyanamid Company, 200 Fifth Ave., New York, has taken over the properties and plant of the Ammo-Phos. Company and will complete its plant at Linden. Several buildings are ready for use.

NEWARK.—The Central Dyestuff & Chemical Company, Plum Point Lane, will erect 4-story warehouse, 75 x 123 ft., cost \$30,000.

NEWARK.—The Western Manufacturing & Oil Company, a West Virginia corporation, have sold a vacant plot to the Upson-Wyton Company of New York, who will begin the erection of separate buildings for rope plant, galvanizing and warehouse purposes, covering about 30,000 square feet.

WHARTON.—The Wharton Steel Company has been bought by J. E. Replogle and will soon be placed under the direction of one of the best-known steel men. The property lies within thirty-five miles of seaport. Several millions will be spent on a new plant.

New York

COHOES.—The Cohoes Rolling Mills have been purchased by Albany interests. Plans are under way to enlarge the output and make additions, so that ultimately 3000 men will be employed. The company is capitalized at \$500,000.

DUNKIRK.—C. A. Friederich, formerly general manager of the Dunkirk Glass plant, is making plans for the establishment of a new glass plant in this city, which will make the third glass plant to be established here since last year.

ELMIRA.—The Elmira Foundry Company, incorporated, has secured options on a big plot of land. This property is not considered desirable for manufacturing until permission has been secured to close certain streets.

NIAGARA FALLS.—The new plant of Isco Chemical Company is operating successfully. The plant was begun on March 25, 1916, by the John W. Cowper Company of Buffalo. The cost of the plant was \$400,000 and it is located on Union St. and Royal Ave. There are nine buildings, equipped with the most modern and complete machinery and apparatus for the manufacture of caustic soda and bleaching powder. The company is connected with the Innis-Speiden Company of New York. The output is sold by this company, the demand being outside of the United States country now being in Russia and South America. Mr. Eben C. Speiden is general manager of the company. The plant has been operating since November 10 and now operates 24 hours per day.

Ohio

CLEVELAND.—Mr. Charles E. Sheehan of Worcester, Mass., will superintend the construction of the new \$400,000 main building of the National Malleable Iron Company to be erected at Woodhill Road and Quincy Ave., S. E.

CLEVELAND.—The National Malleable Castings Co., 7700 Platt Ave., will erect a plant at Belt Lane Rd. and Woodhill RR., costing about \$250,000.

EAST LIVERPOOL.—The National Drawn Steel Company has made a request for a portion of the city farm for an addition to their plant. The capital has been increased from \$100,000 to \$150,000.

MASSILLON.—The National Pressed Steel Company began the erection of the main building on Jan. 9. The company was recently incorporated for \$1,000,000. Mr. H. M. Naugle is general manager. All the machinery and equipment has been ordered.

NILES.—The Basic Steel Company plans the erection of another plant in the Mahoning Valley. W. A. Taylor of Niles is president of the company.

Oklahoma

DILWORTH.—Because of the shortage of natural gas in West Virginia, glass plants may go to other cities. Dilworth has 500,000 cubic feet of gas daily available.

OKLAHOMA CITY.—The Burdett Oxygen Company will begin operation of its Oklahoma plant, located at the Stock Yards Station, Oklahoma City, on Feb. 15, and will be in a position to furnish oxygen to users in that city. The plant is the first plant installed by the Burdett Company in the various industrial centers of the country.

Pennsylvania

ESSINGTON.—Announcement has just been made by the Westinghouse Electric & Mfg. Company that the plot of ground recently purchased at Essington, near Philadelphia, will form a new industrial center for the Westinghouse Electric International Corporation.

The new premises about 500 acres, with a frontage of approximately one mile on the Delaware River. Additional transportation facilities will be afforded by trucks from Philadelphia and Philadelphia and Reading Roads.

This new center will be devoted to the production of large apparatus, the first group of buildings being for power machinery, principally turbines, compressors and reduction gears. The initial development will cost in the neighborhood of \$5,000,000 or \$6,000,000, occupying about one-fifth of the entire plot. The group will consist of the following buildings: two large machine shops, an erecting shop for heavy machinery, forge shop, pattern and pattern-storage shop, and power house. Work will begin on these as soon as satisfactory building contracts can be let.

The number of employees to be engaged at the new plant has not as yet been definitely determined, but will number several thousand people, and undoubtedly will in the future equal the number employed at East Pittsburgh, representing over 20,000 people.

MARCUS HOOK.—The General Chemical Company has purchased two tracts of land, totaling some 100 acres, near Marcus Hook, and it is understood that in addition to a plant a number of houses for employees will be built.

NORTH PHILADELPHIA.—The Scientific Equipment Co., 2951 N. 27th St., Philadelphia, plans the erection of a 3-story warehouse, to cost \$200,000.

PITTSBURGH.—The Raymond Bros. Impact Pulverizer Co., Chicago, Ill., has sold seventeen of its largest roller mills to the Carnegie Steel Company. Representatives of the company are now in Pittsburgh during the last month installing the mills. They are used for pulverizing coal for open-hearth furnaces. Five of the mills were installed at Clairton and twelve at Homestead. Those at Clairton have been set up and put in operation, and those at Homestead are partly in operation.

POTTSVILLE.—The Eastern Steel Company will enlarge its plant in the spring. The company has recently completed several purchases of land.

SHARON.—The Knox Pressed and Welded Steel Company has acquired the Sharon plant for \$1,000,000. The plant has only been operated a short time in its present location, but has been rushed to capacity ever since being acquired.

SHREVEPORT.—The Caddo Oil and Refining Company have filed a mortgage here to-day in favor of the Commercial Trust Company of Philadelphia for \$1,000,000, to cover the purchase of nine local oil and refining companies. The new company will begin at once to expend \$500,000 for improvements and development of properties, which include large acreages in the Caddo and Red River districts.

South Carolina

COLUMBIA.—Mr. Lloyd H. Grandy will erect a paper pulp mill plant to handle 10 cords of wood a day.

COLUMBIA.—The Union Bleaching Company proposes to double the present size of its plant. Improvements will represent an outlay of \$250,000.

Tennessee

CLEVELAND.—The Dixie Foundry Company is enlarging its plant in order to triple its output. The company will manufacture light and medium gray iron castings.

KINGSPOUT.—The new glass manufacturing company, which will employ about 300 men, will erect its plant this year, at a cost of \$150,000. Another company, which will manufacture oak veneer, has located here.

Texas

HOUSTON.—The Sinclair Oil and Gas Corporation will build a 300-mile pipeline from the Haldon oil field in southern Oklahoma to Houston, Tex. The company will then have pipelines running from the Gulf of Mexico to the Great Lakes, the system being about 1500 miles long. A big refinery will also be built near Houston. The company has also gained the concession of 9,000,000 acres in Costa Rica.

Utah

SALT LAKE CITY.—The Cache Sugar Company has issued \$150,000 additional stock and planned the establishment of a sugar plant at Cornudas, Cache County, situated on the Utah-Idaho state line. The plant will cost about \$600,000. The company has a capital of \$800,000. Mr. J. A. Hendrickson of Logan is president; J. Will Knight, of Provo, is vice-president; Lon J. Haddock, Salt Lake, secretary.

Washington

TACOMA.—The Tacoma City Council has entered into contract with Morton Gregory, of 2113 North Anderson St., Tacoma, for the lease of 3300 sq. ft. of floor space on the Municipal Dock property for one year. This space will be used by Mr. Gregory for the manufacture of synthetic rubber. He has spent considerable time in experimenting upon his formula and this last year has tested it out in various laboratories, among others at the University of Washington, where it is claimed, one of the professors made synthetic rubber by following out his process. Work will be commenced as soon as machinery arrives from the East. The lease is protected by under patent rights, both in this country and abroad.

TACOMA.—The Bilwode Alloys Company, producers of electric furnace ferromanganese, has engaged W. K. Booth as consulting engineer. The company is enlarging its present plant at Tacoma and will manufacture ferrochrome, ferrotungsten and silico-manganese, in addition to ferromanganese. A one-ton tungsten furnace, a six-ton ferromanganese furnace and a five-ton ferrochrome furnace will be added.

SEATTLE.—The Rothert Process Steel Company, Joshua Green Bldg., Seattle, has contracted for the erection of four Wile steel mills for rolling or making steel direct from magnetite ore.

West Virginia

CABIN CREEK.—The Ohio Cities Gas Company has planned the erection of a half-million-dollar plant at the mouth of Cabin Creek, near the company's big oil pool in West Virginia. The plant will be used for the manufacture of salt. The territory is in the midst of what are said to be the best gas deposits, with a permanently favorable fuel supply. The plant will handle about 12,000 barrels of salt water daily and it is expected to produce 26,000 tons of salt, 136,000 pounds of bromine, 7000 tons of calcium magnesium chloride annually.

Canada

BRIDGEPORT.—The Canadian Chicago Bridge & Iron Works, with headquarters at 37 St. Andrew St., Chicago, Ill., plans the erection of another plant in the spring.

LADYSMITH. B. C.—The Ladysmith Smelter Company, formerly operated by the Tye Copper Company, an English concern, has been purchased by American capitalists, and \$100,000 will be spent on improvements.

Manufacturers' Notes

THE BRAINARD-FAIRCHILD ENGINEERING CO., 330 Old Colony Bldg., Chicago, has been organized for the purpose of giving engineering assistance in connection with mining and metallurgical operations where crushing and grinding work is necessary. Mr. Brainard is head of the Brainard Pulverizer Co., of the same address.

THE SEARCHLIGHT CO. of Chicago, Ill., has consolidated with the Air Reduction Co. of New York and the Chicago

offices of the Searchlight Co. will be moved East.

SPAIN WANTS CHEMICALS.—The Merchants' Association of New York, through its Foreign Trade Bureau, recently made inquiry regarding the market for oils and chemicals in Spain. Reply has been received from the Consul General of the United States.

"In acknowledging the receipt of your letter of Oct. 10, with reference to extending the foreign trade of a New York firm dealing in oils and chemicals," says the Consul General, "I have to inform you that there is at present a great demand for such goods in Spain."

Aniline Oils and Chemicals

"Aniline oils and chemicals for use in textile industries were formerly imported in large quantities and their lack is now keenly felt by many Spanish manufacturers. To give you a more concise idea of the situation I have tabulated for you a few of the important items in which this decrease is noticeable, showing the amounts imported during the first eight months of 1914 and the period just previous to the outbreak of the war, and during the corresponding period of 1916:

	1914 Metric tons	1916 Metric tons
Coconut, palm oil and vegetable table oils except oil	1,045	781
Vegetable products employed in medicine not given separately	199	90
Products of the animal kingdom employed in medicine	96	39
Vegetable dyeing extracts	2,564	2,043
Mineral products, prepared in lumps and those prepared with water	1,928	755
Colors derived from coal	839	137
Hydrochloric and sulphuric acids	209	20
Nitric acid	19	8
Sulpholeic and other similar acids	47	5
Chloride of calcium	2,543	445

Demand Is Strong

"The demand for drugs and chemicals in this district has been particularly marked during the last two months, many importers, manufacturers and dealers having applied at this office for the names and addresses of exporters in the United States. It has been said that if sufficient supplies of this class of merchandise cannot soon be received in Barcelona, several important industries will be obliged to restrict or even suspend work."

TANTORION NOT DUTABLE.—The United States Court of Customs Appeals in a test case brought by the Bethlehem Foundry & Machine Co. has found in favor of the importers in regard to a duty on tantorion.

The Collector classified the commodity as ferrosilicon, this calling for duty at the rate of 15 per cent. The Board of General Appraisers found in favor of the importers. The Government then appealed to the court for a review of the board's finding. It was shown at the trial that whereas ordinary pig iron contained around 4 per cent of silicon, the tantorion in controversy had as much as 14 per cent. This fact, the Collector explained, warranted the inclusion of the merchandise in the ferrosilicon class.

Judge Martin, in his decision for the court affirming the board, and thereby sustaining the importers, said the evidence showed that the tantorion was ferrosilicon, but essentially differed from it in character and use. The court remarked that pig iron was met with in the trade occasionally with as high a percentage of silicon as high as 16 per cent. It was accordingly held that, while the merchandise in controversy differed to some extent from the average ferrosilicon of commerce in respect to the proportion of silicon it contained, notwithstanding this fact, properly free under the pig iron paragraph.

NEW HOME OF AMERICAN TOOL & MACHINE CO.—The American Tool & Machine Co. dates the foundation of its business in 1843 and with continual enlargement has occupied various localities within the city limits of Boston. Incorporated in 1880, the shops were established at Hyde Park in 1874, and the office for the last twenty years have been at 109 Beach Street. The company perfected and introduced the Weston centrifuge in 1865. During this twenty years the business has greatly increased and the desirability of more modern offices has led to the removal to the Rice Building at 10 High Street.

To accommodate the trade requiring immediate delivery of many productions in power transmission and machine shop requirements a warehouse has been established at 124 Purchase Street, which will be the shipping address. The new offices will be opened Feb. 1.

EMBARGO ON CHEMICALS IN THE UNITED KINGDOM.—The usual general license at London has been renewed under date of January 20 that the following chemicals are under prohibition of exportation: Sulphate of ammonia, prohibited to all destinations; ammonia and its salts, whether simple or compound (except ammonium nitrate, perchlorate, sulphate, and sulphocyanide), to all non-British destinations. These include, in addition, "Ammonia and its salts, whether simple or compound (except ammonium nitrate, perchlorate, and sulphocyanide)," which products were under prohibition to all non-British destinations.

AMERICA'S GREATEST YEAR IN FOREIGN TRADE.—American exports for 1916 reached the unprecedented total of \$5,481,000,000. According to a statement issued to-day by the Bureau of Foreign and Domestic Commerce, of the Department of Commerce, this exceeds the total for 1915 by \$1,826,000,000 and the total for 1914 by \$1,077,000,000. Exports for December are announced as \$521,000,000, which exceeds the previous high monthly total by \$5,000,000. The December average for five years previous was \$263,000,000.

Imports in 1916 aggregated \$2,392,000,000, also a record total. For 1915 the total was \$1,779,000,000 and for 1912, the previous record year, \$1,818,000,000. December imports were valued at \$240,000,000, indicating a continuation of the recovery which set in during September last following the sharp decline from the large total of \$246,000,000 for June. For December, 1915, total imports were \$172,000,000 and the December average from 1911 to 1915 inclusive, \$153,000,000.

The year's export balance was \$3,089,000,000, as compared with \$1,776,000,000 for 1915 and \$2,456,000,000 for 1914. Imports totaled \$2,392,000,000 for 1916, as compared with \$1,818,000,000 for 1915 and \$1,779,000,000 for 1914 inclusive. The December favorable trade balance was \$316,000,000, compared with \$187,000,000 for December, 1915, and \$131,000,000 for December, 1914.

NITRATE OF SODA SHIPMENTS IN 1916.—The total shipments of nitrate of soda to American ports for 1916 was 1,225,637 tons, as against 772,190 tons for 1915.

SCHAEFFER & BUDENBERG ESTABLISHES A ST. LOUIS OFFICE.—The Schaeffer & Budenberg Mfg. Co. of Brooklyn, N. Y., makers of Columbia recording instruments, has announced the establishment of a selling office in St. Louis, Mo., under the direction of A. H. Reuter, who was formerly connected with the Chicago office. The principal offices of this company are now Brooklyn, N. Y.; Philadelphia, Pa.; Pittsburgh, Pa.; Chicago, Ill.; St. Louis, Mo.; Los Angeles, Cal.

TRAYLOR ENGINEERING CO. OPENS CHICAGO OFFICE.—The Traylor Engineering & Manufacturing Co. of Allentown, Pa., has opened a Chicago office at 144 Fisher Building. The office will be in charge of L. J. Hewitt, who for the past thirty-six years has been intimately identified with the stone crushing machinery business of the mid-West, and for the past twelve years has been representative of the Fowle & Moring Machinery Co. in that territory.

MACKINNON, HOLMES & CO. CHANGES MANAGEMENT.—Changes in the management of Mackinnon, Holmes & Co., Ltd., of Sherbrooke, Que., have recently taken place, caused by the retirement from the company of A. R. Holmes, who in the past has occupied the position of director and secretary-treasurer.

It is understood that J. W. Bowman, president, and G. D. Mackinnon, president and general manager, have purchased the holdings of A. R. Holmes and his friends, and new directors in the persons of Dr. A. W. Klein of Greenwich, Conn., M. J. Mackinnon and J. J. Nicol of Sherbrooke, Que., have been elected, with P. C. Johnston, secretary-treasurer.

The business will be continued as in the past under the management of G. D. Mackinnon, and it is understood the company is making extensive plans for future development.

This company has been particularly successful in its general business of structural steel and steel plate work, having one of the most complete machinery concerns in the country for these special lines. It has also been successful in the forging of shells for the Imperial Munitions Board, having a very complete and up-to-date plant for this special work.

MERRIMAC TAKES OVER COCHRANE CO.—The formal transfer of the plant and business of the Cochran Chemical Company to the Merrimac Chemical Company has taken place, the latter concern taking over also the personnel of both offices and factory management. The business of the Cochran company will continue without interruption. Business, however, will be carried on in the name of the Merrimac Chemical Company and all communications should be made to it at 40 Central Street, Boston, Mass.

SEVERAL DIRECTORS RESIGN FROM FEDERAL DYESTUFF CORPORATION.—George T. Bishop, president of the Federal Dyestuffs & Chemical Corporation, resigned this week from that office. George H. Schuler, assistant to Mr. Bishop, resigned at the same time. The resigning directors were Ralph L. Fuller, E. G. Tiltonson, Mark W. Potter and George A. Coulton. It is stated that other interests require the attention of these men. Mr. Bishop is now connected with Ralph L. Fuller & Co., of which Mr. Fuller is the president.

BIG YEAR IN OIL INDUSTRY.—At the annual meeting of the Standard Oil Co. of New Jersey, F. W. Keller, vice-president, said that the unexpected demand for petroleum products 1916 has been a prosperous year in all branches of the business. During the year total production exceeded that of 1915, and the Argentine production was greater than increased production, and this situation is being reflected by advancing prices in crude. The brisk demand for the past two years at the minimum has resulted in the Argentine in production of crude. Outside capital has been used largely in providing this excess and the demand has come, as they do with great regularity in this business, this new capital will be brought to a realizing sense that it is uneconomic to pay for prices for other production and refining capacity. However, concerns that have been conservatively operated will probably on account of the demand continue to enjoy prosperity during the current year.

THE FIRST NATIONAL BANK OF BOSTON OPENS BUENOS AIRES BRANCH.—Arrangements have been completed for the opening by this bank of a branch in Buenos Aires under the management of Noel F. Tribe, a banker of experience, who has resided in the Argentine for the past twenty years and is exceptionally well versed in South American financial and trade conditions. Mr. Tribe will return to Buenos Aires in the near future. The bank's coming month will be very glad to meet at the bank or correspond with those who may care to take advantage of the opportunity to do business with him details of South American business.

This branch was established to assist in building up the foreign trade between the United States and Argentina. As soon as this trade passes through the port of Boston, and as New England exporters and importers are so vitally interested in accurate foreign credit information and dependable financial arrangements, it seems appropriate that this bank extend its activities in this way for the general benefit of our foreign trade.

The First National Bank of Boston is already prominent in financing the foreign trade in the foreign field, having direct bank correspondents in all the financial centers of the commercial world. Due to these connections, which its foreign department has built up in the last fifteen years, soon after the war broke out it took the lead in the foreign trade in business transacted, leading all other banks in this respect.

The advantage of a direct branch in the Argentine is obvious not only to assist in building up foreign trade during the present unsettled trade conditions, but also as a matter of preparedness to assist American retailers and exporters in the percentage of present business as possible after the close of the war.

THE GULICK-HENDERSON COMPANY, consulting and inspecting engineers, announce the removal and consolidation of their general offices from 30 Church Street and 129 Broadway, New York, to 13-21 Park Row.

NITRATE SHORTAGE FEARED BY GREAT BRITAIN.—England fears a shortage of nitrate of soda unless large shipments are soon forthcoming from Chile. W. D. Moorhead & Co., of London, have published a review of the situation for the last half of 1916.

After noting the upward course of prices in Chile during the past six months, they say:

"The fact that even 1915 has shared in the business done at 8s 3d ordinary, and 8s 6d for refined per quintal, is strong evidence that, in some quarters at least, a hopeful view is taken of the industry when, presumably, war will be no more. We have no valid reason for condemning such a policy, but it might perhaps be just as well to exercise caution in the matter of far forward purchases. For, who knows what new features in the industry the necessities of war may have brought about. It is tolerably certain that, even if no new discovery has been made, the mere use of great deal of machinery for the manufacture of synthetic nitrate in Germany which may become, on the basis of its new capitalization, a formidable competitor to the Chilean article. Perhaps, however, the prices now obtaining for 1917 are almost more dangerous from a purchaser's point of view (apart from government purchases), being so much higher, German peace offers must tell upon the nerves of holders and producers when prices rise to giddy heights. So far as the first six months of the year are concerned, we think holders have little to fear unless they have failed to secure their freight, but afterwards there might be more danger, when in view of the fact that the export of Germany to bring about negotiations for peace."

"Twelve months ago some doubt existed as to the capacity of the market to cope with the increase which was taking place, but this fear has been set at rest during this past few months by the market's wonderful power of adjustment. The question is, how long will it last? Should the present rate of production be the maximum, it is hardly likely that it will be found to be too much until the year is over, and that is about all we can say."

The figures of production for the year are 63,300 quintals, against 38,123,000 the previous twelve months. Stocks in Chile at to-day's date are 1,000,000 quintals, a year ago, being about 16,300,000 quintals, against 17,099,000. Freight to-day are very nominal, quotations being about 10s to 150s per ton for sea or steam, but it is doubtful if one would be forthcoming at even 160s.

"The conclusions to be arrived at from these considerations is that nitrate in the immediate future cannot well be cheaper than it is to-day and it may very easily be dearer, nevertheless, barring sulphate of ammonia, which may be obtained in small doses, if indeed it can be had at all, it is probably cheaper than any other form of fertilizer obtainable. The pity is that supplies are so slender."

Manufacturers' Catalogs

DENVER ENGINEERING WORKS COMPANY. Denver, Colo., has issued Bulletin No. 1, January, 1917, dealing with the Dewco ball mills.

MANTOWOC ENGINEERING WORKS. Manitowoc, Wis., has issued a pamphlet describing the Manitowoc dryer.

THE SIDCO COMPANY OF AMERICA, Inc. 37-39 Broadway, New York City, have issued a little booklet "Pure Fused Silica," describing their products, which are made in America.

THE NATIONAL CHEMICAL COMPANY. People's Gas Building, Chicago, Ill., has issued a booklet on potash manufacture from kelp, dealing in its uses, industry and commercial value.

MESTA MACHINE COMPANY. Pittsburgh, Pa., has issued Bulletin "D," booklet on the Mesta automatic plate valves (Iversen Patent).

Other New Publications

THE RADIUM-URANIUM RATIO IN CARNOTITES. By S. C. Lind and C. F. Whittemore. Technical Paper 88, Mineral Technology 6, issued by the Department of the Interior, Bureau of Mines, January 1917.

ITS FUTURE. Chandler lecture at Columbia University. By William Francis Hillebrand, chief chemist of the Bureau of Standards, at Washington, published by the Columbia University Press, New York Agents, Lemeke & Buchner, New York.

BIBLIOGRAPHY OF RECENT LITERATURE ON FLOTATION OF ORES. Compiled by D. A. Lyon, O. C. Ruston, F. Lacey and S. C. Lewis. Technical Paper 35, published by the Department of the Interior, Bureau of Mines, January to June, 1916.

UNITED STATES GOVERNMENT SPECIFICATION FOR PORTLAND CEMENT. Third edition issued Jan. 18, 1917. Circular No. 33 of Bureau of Standards.

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Contents for March 1, 1917

EDITORIAL:

Efficiency and Legislation.....	241
Our Export Trade.....	242
A Little Homily on Reading and Writing.....	243

READERS' VIEWS AND COMMENTS:

The Niagara Falls Power Famine. By W. McA. Johnson.....	244
Research and Industry. By Parker C. Choate.....	244
Coming Meetings and Events.....	245
The Western Metallurgical Field.....	245
The New York Meeting of the American Institute of Mining Engineers.....	248
Nitrate Industry in Chile. By I. Berkwood Hobbsbawn.....	253
The Analysis of Light Oils. By Gustav Egloff.....	259
The Determination of Zinc. By J. H. Hastings.....	263
Hydro-Electric Power and Electrochemistry and Electro- Metallurgy in France. By C. O. Mailloux.....	265
A Bibliography of Alloys: Binary, Ternary and Quaternary Systems Whose Equilibria Have Been Investigated. By Clarence Estes.....	273
Synopsis of Recent Metallurgical and Chemical Literature.....	282
Recent Metallurgical and Chemical Patents.....	284
A Mammoth Gyratory Crusher.....	286
A Remote Liquid Level Gage.....	287
Recent Developments in Operating Sugar Mills.....	288
PERSONAL.....	288
OBITUARY.....	289
Current Market Reports—The Iron and Steel Market, the Non- Ferrous Metal Market, Chemical Market and Price List.....	289
Industrial—Financial, Construction and Operation, and Manu- facturers' Notes.....	293

Efficiency and Legislation

In the engineering of a popular propaganda there is no more useful aid than a well known catch-word. In recent years one of the best words of this kind is "efficiency" which has been brought into considerable popularity by its association with such well advertised things as the manufacture of Ford cars, the German war machine, efficiency engineers, etc. So it naturally followed that those who professed to believe that the Falls of Niagara were running dry should use the efficiency motif in their propaganda. From this it would appear that the rapacious power companies and the greedy electrochemists were not only guilty of trying to ruin a great natural spectacle, but in order to do so were using the water in the most inefficient manner possible.

The great advantage of the efficiency argument was the element of truth contained in it. It is not so many years ago that just below the upper steel arch bridge at Niagara Falls there was a spectacular display of water going to waste and while to some this did not lack picturesque features, to others it suggested criminal waste, while to Mr. Taft and "the representative of the American Civic Association" it gave the impression of "the back yard of a house negligently kept." Certainly there was no denying that the water was not used efficiently. However, it should be observed that this water came from a power canal begun in the year 1853, long before modern hydro-electric construction had reached its present high state of development. Moreover the company owning the development was busily engaged in improving its construction as quickly as circumstances permitted and to-day a very high degree of efficiency has been reached.

As regards the other hydro-electric plant it must not be forgotten that when it was planned and its construction started more than a quarter of a century ago it was a unique development, involving new and difficult engineering problems demanding great courage to face successfully. Those responsible for its creation undoubtedly availed themselves of the best engineering ability to make the experiment successful and it certainly was not a failure. But with the knowledge gained in this pioneer work and with modern experience in hydro-electric design the water taken from the river could now be used with far higher efficiency. Indeed several years ago it would have been possible so to modify the construction of this plant that the water it uses would generate an amount of electric energy closely approaching that theoretically available.

As has been pointed out in these columns before, the plans for such a hydroelectric development have long been in existence, but their execution has been suc-

cessfully blocked by the propaganda of those who profess to be advocates of efficiency. With the addition of a relatively small amount of water to that at present diverted by this plant it would be possible to reconstruct it so as to make it capable of generating 200,000 hp. at the highest efficiency. The much more efficient use of the water in this way has, however, been successfully blocked by the Burton Act and the artificial extensions of its effect and thus the utterly deplorable present situation has come about and every one realizes that something has to be done.

Congress is now considering permanent legislation in reference to the diversion of the Niagara River. So far as the efficient use of the water allowed by the international treaty is concerned the proper course of legislation is obvious. The pioneers in the development, the plants now existing at Niagara Falls, should be enabled in the one case to use water to the full capacity for which it is constructed and in the other to use sufficient water to permit reconstruction so as to bring up the efficiency to the highest point attainable by engineering means.

We might well take an example from Canada where the ideal is the fullest development possible at the maximum efficiency. There a canal starting from the upper river will carry the water to Queenston Heights, thus taking advantage of the greatest head that can be obtained.

This also is the very ideal of the electrochemist since the future of his processes depends on a vastly increased production of electric energy. This should be the ideal of everyone professing a desire for preparedness for war and peace; but is this the ideal of the Washington politicians?

Our Export Trade

Much of the comment made on our export trade during the war tends to produce an exaggerated notion of its character and volume. There is distortion by a psychological influence, the painful increase in the cost of living suggesting scarcity, and scarcity in turn suggesting that the United States has been drained of the things which we, the people, want to buy at a reasonable cost.

Nearly all the statistics of merchandise exports presented in discussions of our foreign trade are in figures preceded by the dollar mark. There is little to suggest quantity; much to suggest value. A collateral fact is that the net vessel tonnage cleared from the United States in the fiscal year ended June 30, 1914, was 53,183,409 tons, while the amount cleared in the calendar year 1916 was 53,150,891 tons, or just the same. In each twelvemonth the vessels were no doubt laden to capacity.

The quantity, on the other hand, cannot have increased greatly. There may have been changes in the character of the merchandise, of course, by which goods of an average greater intrinsic value were shipped lately, and certainly the price per unit of the same goods has greatly advanced. It is unfortunate that with so many commodities it is impossible to present statistics repre-

senting quantities. When such are available they frequently fail to show the demand from the allied belligerents that one might expect. There are quantity statistics, for instance, showing the number of pairs of boots and shoes exported. There is an island near us, in which we take a fatherly interest, the "Pearl of the Antilles," and the ruthless statistics inform us that in 1916, as well as in December of that year, we shipped more pairs of boots and shoes to that island than we did to the next two countries, the United Kingdom and Italy, combined. Yet the cost of footwear in this country goes up.

Indeed, the statistics of vessel clearances show that destinations were much the same last year as in the twelvemonth before the war, about the same proportions to Canada, South America, Europe, and the other continents. There was a trifling decrease to Europe and a fair increase to Asia, which redistribution the Trans-Caucasian railway explains. The tonnage formerly going to Germany and Austria has been made up by the entente allies and that is about all that can be said in this respect.

As to the value of the trade there has also been a disposition to exaggerate. Making allowance for the relatively small merchandise trade balance in 1914, and other necessary corrections, we have grown richer with our foreign trade up to the beginning of this year by only about four billion dollars. Before a careful study was made there were estimates that five or six billions of American securities were held abroad and they were all expected to come back to us. Investigation showed, however, that the amount was considerably less than four billion, while only about one and a quarter billion has come back.

It is true that we have purchased of foreign securities about two and a quarter billion. That may seem like a large amount, but England alone has borrowed about eighteen billion. We are very far from being England's chief banker. As to gold, a distorted view may easily be obtained, because gold as a basis for currency is one thing and gold as a representative of wealth quite another thing. With the stream that has been poured into the country, we have not only more gold as a sum, but more gold per capita, than we had of all kinds of money two decades ago when our late Secretary of State refused to be crucified upon a cross of gold—because there was not enough of it. Our net gold imports in three years have been only about three-quarter billion dollars, which is a great deal for a circulating medium but does not represent much wealth. Our railroads alone are capitalized at 28 times as much. Let us as a nation keep our nether garments on and realize that we still must work. There is no escape from this conclusion.

No small part of our export trade has been in iron and steel. The value of iron and steel exports in 1916 was \$867,323,044, according to the Government classification, which does not include in the category agricultural implements, railway rolling stock (except locomotives), automobiles, etc., although these goods contain much iron and steel. The value stated was 16 per cent

of the total value of exports. On account of our very small imports of iron and steel, practically negligible, the contribution to the trade balance was much larger, 27 per cent.

A Little Homily on Reading and Writing

It was the first lecture in the class in modern history at a leading American college which turns out good men. Its degrees are highly valued for good and sufficient reasons. The professor stated that he had no ambition to make his class letter-perfect in the dates of history; what he hoped to do was to give them a broader vision of the affairs of to-day and a better understanding of reactions in the mass of humanity. We appear, he said, to be at the brink of war, and the immediate cause of it may be the drowning of one or more citizens. But that, he continued, will be but the incidental cause; the real causes go back a hundred years; there are mistakes that have been made; cardinal mistakes, egregious blunders which, when they were committed, seemed marvels of astuteness, but which are the real causes of the present calamity.

In order to give the subject more vital interest and to make it more memorable to them he would make his lectures chiefly biographical; but for this they would need to have in mind a reasonable historical background. So he proposed to recall to them certain books with which they were probably familiar or, if not, to make them a part of their collateral reading. The parts played by men of mark in the chess-game of the peoples would then be understood.

He wondered how many had read Chesterton's Victorian Age. The class was large, but only two had ever heard the name of Chesterton. These two had also read the book mentioned. Trevelyan's Garibaldi, and the Thousand and The Making of Italy were inquired into. Of the same two students one had read Garibaldi and the Thousand, but none of the others had ever heard of Trevelyan. Thayer's Life of Cavour was totally unheard of and so was Edmund Gosse's Father and Son just as well as Money Penny's Disraeli.

They did not even know Mr. Brittling. One of the particular two had read Samuel Butler's Way of All Flesh and the other had looked at the title of Erewhon, but nobody else had ever heard of Samuel Butler. And so he proceeded through a popular list of the real contributions to literature made during the past ten or fifteen years that are indicative of the folkways. They were terra incognita to all but the two students we have mentioned.

Of all the books spoken of it is doubtful if any member of his class would have failed to finish a single one of them had he once begun to read it. They just did not know about them. They were typical Americans of good stock with the exception of the two who knew a book or two. Of these the one who had the better reading in English was born in Warsaw, Russia, and had first learned Yiddish and then Polish while the other was a young German, interned by the war in this country.

What's the matter with those American boys? They are fine fellows, sound young men, good students and they promise well, but the fact that they are ignorant of the literature of their own language, that they have no nose for that which bids fair to be permanent, shows something wrong.

We have no desire to hold the two foreign students up as having greater merit than the others. It is doubtful even if they have read more; the difference in this respect is that they have read good books, while the others have read trash. They had the good luck to strike something worth while that the others did not know about. Surely there is just as much sport in Garibaldi's life as there is in the imaginary career of any Dare-devil Dick who ever dodged bullets or rode an ostrich in a musical comedy. The explanation, we think, is to be found in one of those sequelæ of democracy which need constant watching. The foreign students were brought up to recognize authority. This may, and again it may not, have inhibited their initiative and narrowed their vision—that is another question entirely.

The only point we desire to make here is that, being accustomed to recognize authority, they betook themselves to the best available source of information as to what books they should read. The others didn't want any highbrow stuff put over onto them, and so they followed the lure of the magazines with their blurbs. The result is, they are not equipped to study contemporary history or even to express themselves in measures of grace.

Complaints are heard on every hand of good and competent engineers who are lacking in the ability to make clear reports or to state conditions so that intelligent laymen can understand them. They can work, but they can neither talk nor write. Sometimes the development of a great undertaking depends wholly upon their ability to talk or to write, and here is where they fall down. So the demand has become general for a larger measure of cultural studies and consequently for more time to be devoted to engineering courses. More or less radical changes have been proposed in the courses, but it is a question whether the solution can be found at all in that way.

Far be it from us to decry the beauties of classic lore, the marvelous treasures of Greek literature or the fascination of Gothic Days and the Renaissance. But some boys must hurry, really hurry, and the opportunity is not given them to take an arts course. Nevertheless, for every one who has taken his engineering degree and who lacks adequate general culture to speak or write without shaming himself, we can point to one or more bachelors of art who are no better off. Slipping through Greek and Latin will not turn the trick. On the other hand, we venture to say that any boy who comes to college with an established taste for that which is well and competently said in literature will not be at loss for the means to express himself when the time comes, no matter how much he may have had to skip and skimp by force of circumstances.

Readers' Views and Comments

The Niagara Falls Power Famine

To the Editor of Metallurgical & Chemical Engineering

SIR:—The relations between the government, the people at large, and the electrochemical industries of Niagara Falls have never been publicly and adequately explained, as far as I can see.

The fundamental psychology of the situation is about this. The people or the state own by the right of eminent domain, the Falls. They have a certain enjoyment of them at present and it is their own way of enjoyment. Now, it is all theirs.

If on the other hand the Falls, all or in large part, were used for power, they would see only factory buildings. Then, none of it would be theirs.

If, however, these factories were opened to the public in such a way that no substantial harm were done to private interests, "the beauties of electrochemistry" could be seen and enjoyed by some means by the people; then in due course the people would allow of an increasingly greater use of the Falls. The solution though easy in theory would be very hard in practice, but it can be done by such very able men as operate at Niagara Falls. But to me this psychology is sound.

In addition, I suppose that a tax would be placed on the power, for the trend of government is socialistic, not on Marxian lines, but by Socialism by Taxation.

W. MCA. JOHNSON.

Hartford, Conn.

Research and Industry

To the Editor of Metallurgical & Chemical Engineering

SIR:—The comment in the paper of Dr. G. W. Thompson (issues of Jan. 15, p. 79, and Feb. 1, p. 149) on the personnel in the development of chemistry really involves the whole subject of research in chemistry and metallurgy. With such able introduction there should be discussion, which is part of his remedy, publicity.

Having spent a life in research involving contact with several large industrial bodies I may be permitted to present the fallacy of present industrial relations to invention or research, with a remedy, and aid in spreading the idea that inventors, industries, and as a consequence the people, are heavy losers, and handicapped in competition with more progressive nations, because of present conditions.

Our industrial corporations must finance research as they possess the only adequate capital and through them the country must get the practice and there must be profit to research and industry.

The industrial personnel is mentally a very different body from the research personnel. This is true both in the capitalists, salesmen and business whips that constitute the directorates, and in the engineers and superintendents and executives that conduct the manufacturing.

The mind that finds the way to do new and improved things must see visions that are entirely obscured to the minds that finance, direct, manufacture and market.

The university professor or the historian and statistician is not in the research class.

All these accept the results of research as existing, and depend upon it for future advance.

We must acknowledge the past existence and future necessity of a mentality that is necessary for civilization as it exists and must exist in any advance. Chemistry and metallurgy form a very large portion of this underlying creation.

It is ably said that the one thing that boards of directors cannot control or direct is invention. Let us define two or perhaps three kinds of invention or research.

First, we have the true scientific discoveries that are useful purely to the scientist, produced largely by our university professors, supported by salaries, and supplied with the adequate bench laboratory apparatus.

Second, we have the radical industrial invention that applies science, finds means and details, and requires in recent times large capital expenditures that are nowhere provided for; yet this is directly the basis of industry that earns dollars and means material saving in the efficiency of life. It is this class of practical invention that has the greatest dollar value and that is more especially the subject of this digest.

Third, we have the invention that maintains efficiency in present known industrial development, closely allied to testing and standardizing, and this department of research is attempted and represented by our many research equipments in universities and industrial laboratories.

The classifications mingle, and there are at least two examples where the second class of research is conducted by industries. But it may be said that a large part, perhaps more than half of the second class of invention, is derived from independent minds not corporation-ruled, as to where they must invent, or chained by the organization necessary in economical industrial practice.

These minds see the vision, design the details and describe the conditions, and appeal to an industry that is interested, to procure the perhaps large amount of money necessary to demonstrate. If they meet acceptance they are asked to assign all rights as a first step, and are offered a salary that may stop, and are promised some reward if successful, yet no definite time for test or degree of use or a tangible promise of any size is made irrespective of value in sight.

In all the forms offered to the inventor for development of research the control is demanded by capital, irrespective of the cash involved or the future prospects, and no adequate cash is promised to enable the inventor to perfect his demonstration on a convincing commercial basis.

The business end demands control of research development—the one thing it does not understand—and it holds the power to proclaim failure before the tests are half completed, and, if a success, it may squelch the invention or do with the minority as it chooses.

Outside of the business argument involving dollars which is always a war, let us consider the effect of this form of control over minds that are about to create a thing necessary for civilized progress—practical applied invention. The result of this control is to incapacitate research mentality and create a loss, and perhaps often a useless expense, simply because industry is trying to direct and govern research as it does direct manufacturing and salesmanship.

When research has completed its commercial demonstration, free from any dictation by business, then it is proper and right that business should have the entire direction as to the degree, time and means to be employed in the application.

There can and should be ample consultation, but the dictation and direction must be well defined, if we seek efficiency in results, and the reward of research must be its commercial creation, and the reward of business the profits of manufacture and sale. This is the pur-

pose of our patent laws. The community ultimately benefits. But how can we do this?

Mr. Thompson desires greater publicity so that there will be a popular demand for more recognition of research and he is entirely correct. But even if this is granted the dictation and impotent direction of the research mind by the business mind will produce as inefficient results in research attempts as would the direction of business by the research mind.

There are, of course, many solutions in practice and I will present one that seems in keeping with the times and about to be recognized as necessary. The incorporation of the Research Corporation of New York to impartially administer royalties has been successful and will be followed by many others on similar lines.

The recent decision of the Supreme Court in the flotation litigation shows that commercial invention put into practice will be protected.

But it would be much wiser if these valuable sustained patents were not held by private corporations solely for private gain, but were held by the inventor who would be sustained by the industries that desire to use the invention, while the royalties were administered in a mild, fair way by impartial boards. Such boards can be easily created as needed.

Large sums of money are needed and research demonstration must be on an adequate commercial scale, yet nothing is more demoralizing than an attempt to conduct research at a manufacturing plant or use the staff connected with manufacturing effort.

Large capital calls for union in research. Union research would mean that several manufacturers interested in lines that use some invention or series of inventions, went under contract to advance adequate sums of cash to a pure research corporation, which in turn would agree to try out and prove certain things desired, and perhaps others as discovered.

The impartial referee board would decide on the royalty, which is paid to the research corporation to sustain research and compensate the inventor and enable the patents to be defended in court. This condition in some form must arrive and it is much cheaper and a much better research incentive for industry to anticipate it and aid it than to fight private greed which will become possessed of inventions of value.

No inventor will hesitate to enter into an arrangement of this kind, and the abler ones will by necessity lead and direct. Business and capital must be kept out except in an assisting capacity.

The attitude of corporations is usually not intentionally to kill research, and men like Mr. Thompson are honest and sincere, whom any inventor could trust personally, but they are servants of an inert body not organized for research which body can only conduct research by the means of business they understand.

I have seen so much of what I state in my past thirty years of pure research effort in metallurgical lines that the exception will but prove the rule.

Let my advices not be misunderstood as though I was feeling that I underrate the industrial engineer or the operating staff, for in their line they are wonderfully able and absolutely necessary, but when they attempt to direct or conduct research the average is as much against them as when the research mind attempts to conduct manufacturing.

I trust I have brought out the great value of each type of mind, its necessary environment, and shown how easy it is to make each more efficient by a proper contract system of relations governed by a clearing house. Mr. Thompson, as I personally know him, freed from corporation cares would be one of those rarely constituted minds who could direct research.

Essex, Mass.

PARKER C. CHOATE.

Coming Meetings and Events

American Chemical Society, New York Section, Twenty-fifth anniversary. Chemists' Club, New York, March 9, 1917.

American Chemical Society, spring meeting, Kansas City, Mo., week of April 9, 1917.

American Electrochemical Society, spring meeting, Detroit, Mich., May 2-5, 1917.

American Society of Testing Materials, Atlantic City, June 26-30, 1917.

Third National Exposition of Chemical Industries, Grand Central Palace, New York, week of Sept. 24, 1917.

American Electrochemical Society, autumn meeting, Pittsburgh, Oct. 3-6, 1917.

The Western Metallurgical Field

Mills

Throughout the mining districts of the North American continent new mills are being erected or plans made for the construction or enlargement of mills. This activity in the increase of the output of ore all over the country is a sure sign that both the mining and metallurgical industries anticipate a boom in their respective lines of business for the next few years.

The mill of the *A. R. G. Mining Company*. This is a new mill, operating in the Joplin district and is located on a tract off the Barrat land north of Duenweg. The mill is one of the most modern in the district, the crusher, rolls, hoppers, sludge tables, jigs and other machinery and equipment all being set on concrete base. This feature not only increases the life of the plant, but also gives a smoother running of the machinery. The jigs are composed of two four-cell roughers and one seven-cell cleaner. The sludge tables are run continually to catch the fine ore. The capacity of the plant is 400 tons per day. The ore treated is high-grade material, and the mill is so constructed as to eliminate all chat from the final product, which may run as high as 63 per cent metallic zinc.

Other innovations made in the Joplin district are: The rebuilding of the 200-ton mill of the *Near By Mining Company* and the erection of the new 300-ton mill of the *Adirondack Company*. The *Near By Mining Company* is reconstructing the L. J. Stephenson mill, which lies between Webb City and Carterville. The mill needs little changing, the main features being the installation of electric power instead of steam and the addition of a few sludge tables for handling the fine ore. The new mill of the *Adirondack Company* lies in the western part of the Joplin district, and the construction is well under way and is of the most modern type.

The *Midvale Minerals Plant* is now in active operation. The plant was erected at the cost of \$100,000 and treats 300 to 400 tons of lead-zinc tailings per day. The mill is retreating the dump of the U. S. smelter at Midvale, Utah, the tonnage of which is so large that it is impossible to estimate it with any degree of accuracy. Other indications of an increase in the output of metals in the State of Utah are the erection of a 250-ton mill on the property of the *Keystone Mine* and the contemplated erection of a mill on the property of the *O. K. Silver* of Indian Springs in Tooele County.

In Canada, too, a lively increase in activity is noticed. A new high-grade mill is in operation at *The Mining Corporation of Canada*. The plant is an addition to the mill of the *Cobalt Reduction Company*. Previous to this the slimes from the concentrator were cyanided in the low-grade cyanide plant, and the sand concentrates were sent to the smelter. From now on the sand con-

centrates will be treated in the new mill together with the high-grade ores from the mines of the corporation, and in a short time all the shipments of the Canadian Mining Corporation will be in the form of high-grade bullion, which will be marketed in London. The new plant differs from the two other high-grade plants in the camp in that amalgamation plays no part in the process nor is the ore crushed in cyanide solution. The ore is first slimed in a tube mill, and after a preliminary treatment in two stages is de-watered and washed on an Oliver filter, then given a cyanide treatment and again filtered on a second Oliver. The silver is precipitated from the solution by means of sodium sulphide instead of aluminium dust. The silver sulphide is de-sulphurized, pumped to filter presses and refined in reverberatory furnaces to a high grade bullion, which is cast in bars and shipped to England.

The installation of a new mill is also under consideration at the *Lake Shore Gold Mines, Ltd.* The plans are now being worked out, and as the road of approach is rather difficult, it has been decided to have the necessary machinery hauled as soon as possible, so that construction may be started in the early part of next summer. The *British Columbia Copper Company* at present is erecting an experimental mill on the Similkameen River, which will be used for the working out of a concentration process preliminary to the erection of a 2000-ton plant at the same place.

Copper

Prospective Increase of Copper Refining Facilities.—A serious phase in the stage of the metallurgy of copper has faced this country for several months, namely, that the mine and smelter output has by far out-run the refinery capacity. The copper producers, while having made epoch-making sales, may find difficulty in making the required deliveries in the near future unless steps are taken to increase the number and capacity of the refineries in the United States. Having realized this dilemma, the "Boston News Bureau" has made a thorough canvass of the refineries for statistics bringing forth the actual prevailing conditions, a summary of which may prove of value. The following tables indicate the present monthly and annual capacities of the various refineries, and also the same after having completed the contemplated improvements and enlargements. The output is given in pounds per month and pounds per year.

	Present		Prospective	
	Monthly	Annual	Monthly	Annual
Am. Smelt. & R.				
Cu.	76,000,000	912,000,000	115,000,000	1,380,000,000
Anaconda	55,000,000	660,000,000	60,000,000	720,000,000
Nicholas	35,000,000	420,000,000	40,000,000	480,000,000
U. S. Smelting	17,000,000	204,000,000	20,000,000	240,000,000
Balbach	5,000,000	60,000,000	5,000,000	60,000,000
Totals	188,000,000	2,256,000,000	240,000,000	2,880,000,000
	Monthly		Annual	
	Present	Prospective	Present	Prospective
American Smelt. & Ref. Co.	40,000,000	60,000,000	480,000,000	720,000,000
Baltimore	20,000,000	25,000,000	240,000,000	300,000,000
Perth Amboy	16,000,000	30,000,000	192,000,000	360,000,000
Tacoma				
Totals	76,000,000	115,000,000	912,000,000	1,380,000,000
Anaconda				
Haritan	35,000,000	40,000,000	420,000,000	480,000,000
Gt. Falls, new	15,000,000	15,000,000	180,000,000	180,000,000
Gt. Falls, old	5,000,000	5,000,000	60,000,000	60,000,000
Totals	55,000,000	60,000,000	660,000,000	720,000,000

These improvements, it is understood, will not be completed until about June, 1917, and a shortage in the delivery of the finished material is therefore anticipated by the producers.

Copper from Mine Water.—The Butte-Duluth leaching plant has resumed operations under the direction

of interests associated with the Ohio Copper Company of Utah. This plant originally recovered copper from mine waters by electrolysis of the sulphate solution. At present the copper is precipitated on iron scrap, giving as final product cement copper. This change from the electrolytic to the precipitation process is a marked advance in the economical handling of the mine waters, the electrolytic process having been one of the most expensive features of the Butte-Duluth plant. The iron used in the form of scrap iron, tin cans, etc., is collected throughout the vicinity and thrown into the troughs through which the mine waters circulate. It might be suggested in this place that in case of a shortage of scrap iron, etc., spongy iron would prove of great value.

Platinum

Platinum Indications in Colorado.—The metal platinum so much desired in some of the chemical industries at the present is valued so highly that there is much interest in locating new sources for the production of this valuable element. At present there is undoubtedly a shortage in this country in metallic platinum and its salts, due to the fact that by far the largest amount of the world's platinum comes from Russia. Only a very small amount of platinum is produced in this country, and that comes mainly from the gold and silver bullion refineries. A. Lynn de Spain, chief chemist of the Burnhart Laboratories of Denver, states that platinum is found in the auriferous sands of the Iron Hill placer at Como, Col. In these sands the platinum is mechanically combined with magnetite. There is no doubt whatever that platinum also occurs in other localities of the State, as, for instance, in the black sands of Clear Creek. Little or no attention has been paid to the finding of platinum in Colorado, first because the rich gold finds have completely obliterated the importance of the other rare metals, and secondly, due to the fact that the average prospector is unable to recognize the metal or ores carrying the platinum. It is therefore essential that more attention be given to spread the characteristics of this metal so as to instigate the search for this metal by the prospectors.

Ozokerite

Ozokerite Plant at Soldier Summit, Utah.—Previous to the European war practically all of the ozokerite used in the industries came from the province of Boryslau, Galicia, Austria. Although it was known since 1879 that ozokerite occurred near Soldier Summit and near Colton, Utah, little was done to develop these resources, due to the fact that it was impossible to compete with the Austrian output. Since the outbreak of the war, Austrian ozokerite is no longer on the market, and as this product has a great field of application the home sources and their successful operation became an item of paramount interest. The only known commercial deposit of this valuable material in the United States lies in Wasatch County, Utah. This deposit is approximately 2 miles in width and 12 miles in length. Further development indicates that the deposit also possesses great depth. The ozokerite occurs in fissure and brecciated zones caused by fracturing of the rocks. The deposits enlarge from mere films to 6 and 8 in., while deposits as thick as 3 ft. have been found. The country rock, as a general rule, is sandstone, while the fractured zone ranges from 10 to 200 ft. in width, the brecciated zone being permeated with seams, gashes, bunches and even bodies of practically pure ozokerite wax.

According to Heath M. Robinson, the Utah ozokerite is a mixture of hydrocarbons in various proportions, the exact nature of which is a subject of dispute. The

color of ozokerite varies from black or dark brown to light yellow, while some specimens of a greenish color have been found. It is plastic without being soft, and hard without being brittle. These latter qualities make it extremely valuable in some industries. The melting point of ozokerite lies between 58 deg. and 80 deg. C. It is soluble in ether, petroleum, benzine, turpentine and carbon bisulphide. Alkalies and the strongest of acids have no effect on ozokerite. It is an excellent non-conductor for electricity, and is therefore extensively used in making insulators. Being waterproof, it is used for lining tanks in which strong acid solutions are used. In the manufacture of candles ozokerite is used to give higher illuminating power. Wax figures and wax dolls are made of this material. Further applications for ozokerite are the manufacture of hard rubber, in electrolytyping, in making phonograph records, in the manufacture of buttons, shoe polish, waterproof crayons, etc.

Ceresin, the refined product of ozokerite, is a substitute for carnauba wax, and is used in the manufacture of floor polishes, wax pastes, shoe and leather polishes, molding mass for copper and silver plating, wax for insulating electric cables, and composition for waterproofing cartridges. It is also used in making sealing wax, ceresin marking pencils, vaseline, cosmolene, molded ceresin candles and dozens of other products of industry.

Considering the wide scope of application of ozokerite and the sudden disappearance from the market of the foreign product, it is not to be wondered at that enterprises were undertaken to develop our own resources. For a year past the Wasatch Ozokerite Company has been in operation at Soldier Summit, Utah, endeavoring to put on the market their product. The treatment required to produce pure ozokerite is very simple as such, the main improvements being mainly along mechanical lines. Initially the company employed large vats, into which the crushed raw material was placed and subjected to treatment with hot water. This heat was sufficient to release the ozokerite from the adhering impurities. The wax, on rising to the surface was then skimmed off and poured into molds and allowed to cool. In this form the product was ready for the market. This mode of procedure proved rather inefficient, so that at present the company is operating steam-jacketed tanks in the treatment of the crude material. A new change is now contemplated by the company, namely, the installation of a cold-water process. The first unit of this process will raise the capacity of the plant from 10 tons of crude material to 60 tons per day. After completion the plant is expected to handle 1000 tons of crude ozokerite per day. With the present capacity of 10 tons of raw material, the plant is producing 400 lb. of ozokerite wax per day, which finds a ready market at 30 to 60 cents per pound.

The industry is undoubtedly here to stay, as it has been found that the deposits are much more extensive than was originally surmised, while the Galician deposits are known to have decreased enormously, and have also been damaged by the war to such an extent as to make their reworking very difficult. In the meantime the commercial development of the field in this country has made it possible to produce ozokerite wax and its refined products so cheaply that the home production will be able to compete with Austria, even though the Galician deposits be again put into operation after the war.

Company Reports

Report of the Old Dominion Copper Mining & Smelting Co. for 1915.—Due to the heavy repairs required at the mill and to the flotation work the cost per ton for

concentration was higher in 1915 than in 1914. The costs were \$1.215 for 1915 as compared to 0.932 for 1914. Much experimental work was done on flotation, and it was finally decided to use the Mineral Separation machine, but continue the investigation on other machines. Changes have also been made in the concentrator to reduce the power cost. These changes were justified on considering that the copper recovery for 1915 was 85.27 per cent, as compared with 73.55 per cent for 1914. The accompanying table summarizes the concentrating operations for the years 1914 and 1915:

	1915		1914	
	Dry Tons	% Cu.	Dry Tons	% Cu.
O. D. ore.....	32,560	3.72	30,101	4.69
Custom ore.....	140,486	4.48	121,792	4.67
Total and average.....	173,046	4.34	151,893	4.67

A comparison of smelting costs for 1915 with the previous year shows as follows, based on tons new charge smelted:

	1915	1914
Tons charge smelted.....	\$2,755	\$2,669
	206,549	207,595

The main items causing the increased cost per ton for 1915 were labor, repairs and increase in cost of flux. The coke consumption decreased 6 cents per ton of charge.

The cost of converting per ton of fine copper produced in bullion in 1915 compares with the previous year as follows:

	1915	1914
Pounds blister copper produced.....	\$5.36	\$5.65
	27,960,091	30,448,901
Pounds fine copper produced.....	27,736,158	30,210,361

The costs were decreased during the year, notwithstanding the fact that there were 2,500,000 lb. less copper produced in 1915 than in 1914. The saving was largely effected in the items of repairs. The cost of handling bullion in yards has been appreciably reduced. Of interest is the fact that the converter shell that was blown in on June 27, 1913, finally came off the stand on Dec. 7, 1915, after having produced 70,800,000 lb. of bullion. Due to the fact that there was no reserve stand to relieve it, and that the entire matte production of the smelter was handled by this shell, its campaign constitutes a most remarkable record. The lining costs per ton for the recently removed shell were \$0.055 per ton of bullion, while the best results that could be obtained under the old acid type practice was \$1.80 per ton of bullion.

Eighty-First Meeting of Faraday Society.—The eighty-first ordinary meeting of the Faraday Society was held on Monday, Dec. 18, 1916, at the Institution of Electrical Engineers, London. Sir ROBERT HADFIELD, president, and subsequently Prof. ALFRED W. PORTER, presided at the meeting. The papers presented were as follows: "A Carbon Tube Furnace for Testing and Softening Points and Compressive Strengths of Refractories," by Ezer and Edgar A. Griffiths (National Physical Laboratory); "Do Equilibrium Solutions in Iron Possess Equal Resistances?" by E. D. Campbell (University of Michigan); "Grain-Growth in Deformed and Annealed Low-Carbon Steel," by Ralph R. Sherry (Detroit, Mich.); "The Union of Glass in Optical Contact by Heat Treatment," by R. G. Parker and A. J. Dalloway; "The Effect of Pressure on the Equilibrium Constant of a Reaction in a Dilute Solution," by W. C. McLewis.

Fellowship in Low-Temperature Coking.—The American Creosoting Company has established an industrial fellowship at the University of Illinois. They have supplied the necessary funds for erecting an experimental coking plant.



PHOTOGRAPH TAKEN ON EXCURSION TO WEST POINT

Annual Meeting of American Institute of Mining Engineers

The annual meeting of the American Institute of Mining Engineers was held in New York City from Monday, Feb. 19, to Thursday, Feb. 22, inclusive.

Technical sessions were held on both the mornings and afternoons of Monday, Tuesday, and Wednesday.

The annual business meeting was held on Tuesday morning. President Ricketts had been ill, and while he was present and on the platform he turned the chair over to Vice-President Prof. Joseph W. Richards. The minutes of the previous annual meeting and the various regular reports were read and passed. Dr. Ricketts said a few graceful words, but postponed the greater part of his speech for the banquet on Tuesday evening.

The result of the election of officers was announced as follows: President, Philip N. Moore of St. Louis, Mo.; vice-presidents, Charles W. Goodale and Mark L. Regua; directors, Robert M. Raymond, W. G. Miller, Allen H. Rogers, Howard M. Eavenson, and J. E. Johnson, Jr. Decision on the simplified spelling was reserved until the directors decide what to do with some 350 unmarked ballots.

Mr. Hennen Jennings read a short report on the activities of the Joseph A. Holmes Safety Association.

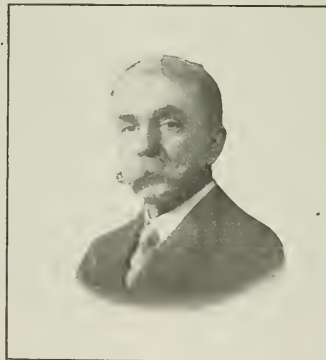
The presidential election this year furnished some real excitement for the members. When they received their ballots for marking they found not one name but two—one the regular candidate of the nominating committee and the other an independent whose name was placed on the ballot by virtue of his large number of petitioners. The race was very close, with Mr. Moore receiving something over 1200 votes and Mr. Sidney J. Jennings receiving between 1000 and 1100 votes.

The entertainment features started on Monday evening with a reunion smoker. The fifth floor of the Engineering Societies Building was crowded and the members were seated in groups according to the colleges which they represented. A treat was furnished in the form of moving pictures of the front in Europe, David H. Browne read some funny stories of boyhood days in Ireland, speeches were made by Messrs. Sidney Jennings, Philip N. Moore, R. M. Raymond and Herbert C. Hoover. Mr. Hoover was given a great reception.

The annual banquet on Tuesday evening at the Hotel Astor was preceded by a reception to Dr. and Mrs. L. D. Ricketts and Mr. and Mrs. H. C. Hoover as guests of honor. At the banquet, speeches were made by the retiring president, Dr. L. D. Ricketts, by the president-elect, Mr. P. N. Moore, and by Mr. H. C. Hoover. The speeches were brief and the time saved by the omission of the usual long after-dinner speeches was spent in after-dinner dancing, which proved very popular and enjoyable.

On Wednesday evening Dr. Herbert T. Kalmus gave an interesting exhibition and lecture together with experiments on a new method of projecting moving pictures in colors, known as the technicolor process. On Thursday an all-day excursion was made by special train to West Point. An exhibition of riding by cadets was witnessed in the morning, luncheon was served in Cullum Memorial Hall, followed by dancing, and speeches were listened to in the afternoon in the auditorium of the Hall.

An exceedingly attractive program of events was furnished for the ladies under the supervision of the ladies' committee during all the days of the meeting. Mrs. H. W. Hardinge was chairman and Mrs. Bradley Stoughton, secretary.



PHILIP N. MOORE
President American Institute of
Mining Engineers

Grain Growth in Metals

This subject was discussed in the session on Metallography Monday morning, at which H. M. BOYLSTON presided. Two papers by Prof. HENRY M. HOWE and one paper by Prof. ZAY JEFFRIES were read. Professor Howe's papers were read by Professor Campbell. Professor Howe's first paper on "Recrystallization After Plastic Deformation" was a discussion of a paper by Mathewson and Phillips on brass presented last year. His other paper was a discussion of Mr. Jeffries' present paper on "Grain Growth Phenomena in Metals." Mr. Jeffries' paper was also a discussion of Mathewson and Phillips' paper. Mr. Jeffries' paper gives a very clear explanation of the phenomena of grain growth, and states that for every metal there is a temperature (designated the germinative temperature by Professor Howe) at which grain growth commences. The germinative temperature decreases with increase in deformation, and coarsening is influenced by the rate of heating, being greatly retarded by passing quickly through the germinative range. Another important



OF THE AMERICAN INSTITUTE OF MINING ENGINEERS

point is that the rate of coarsening is greater for a higher germinative temperature.

In the discussion on this subject Mr. W. F. Ruder said he had previously considered grain growth to be a critical strain phenomenon. He cited an experiment corroborating the statement that the germinative temperature decreases with increase in plastic deformation. Mr. Carter said he had made some experiments on platinum-iridium alloys. With pure platinum recrystallization occurred at about 1000 deg. C., with platinum-iridium at 1100 deg. C. or over, depending on the percentage of iridium. At 30 per cent iridium the grain does not grow with continuous heating to the same size as in a 20 per cent iridium alloy. Prof. J. W. Richards thought that metallurgists would find a great deal in Professor Bragg's work on crystals to aid in this study. (An article on Professor Bragg's work appeared in this journal July 1, 1916, page 35.)

Tungsten-Molybdenum Alloys

Two papers on this subject were presented in the same metallographical session, one by ZAY JEFFRIES and one by F. A. FAHRENWALD. Professor Jeffries described a new method of determining the melting points of tungsten and molybdenum alloys. A summary of Professor Fahrenwald's paper follows:

1. By compressing the mixed reduced powders of tungsten and molybdenum into briquets and then heating with an electric current in an atmosphere of hydrogen, alloys of this series were prepared varying in composition from 100 per cent tungsten to 100 per cent molybdenum.
2. The solidus curve for the series was located by means of optical pyrometer temperature measurements and checked by comparing the fusing current with a standardized wattage-temperature curve.
3. The equilibrium diagram for this series shows no critical points, appearing as resistance fluctuations, corresponding to a separation of a new phase. Its construction has been based upon this fact and upon results of microscopical analysis.
4. Curves for hardness, and for equalizing temperatures, are smoothly convex, being typical of an uninterrupted series of solid solutions (mixed crystals).
5. As a result of thermal and microscopical analysis, the metals tungsten and molybdenum are reported to be completely isomorphous.
6. All alloys of this series are malleable and ductile under proper conditions.

In discussing Professor Jeffries' paper Professor J. W. Richards suggested that the logarithm of the wattage should be plotted against temperature instead of the wattage, thus giving a straight line instead of a curved line.

Milling and Smelting

This session was held on Monday afternoon, SIDNEY J. JENNINGS presiding. An interesting paper on "Magnetic Concentration of Low-Grade Magnetic Iron Ore" was presented by S. NORTON and S. LEFEVRE. The paper describes the Ball-Norton separators and discusses present practice at the plants of Witherbee, Sherman & Co. at Mineville, N. Y. Various other wet

and dry tests are described. The authors' summary is as follows:

The known and partially developed orebodies of New York and New Jersey could, if equipped with the best modern mining and milling machinery and using the best methods, produce at the present time 25,000 tons of 60 per cent iron ore per day. This can be delivered for an average freight charge of \$0.75 per ton from mill to tidewater. The operating cost of production should reach the "dollar rock" ideal of the Lake Superior Copper region, and the cost of mining and milling one ton of crude ore should be about \$1 for underground mining when handled in large quantities. The ratio of concentration would be two tons of crude per ton of concentrates for an average. There are reserves of magnetic ore sufficient to double the above production, and then last probably 100 years.

In discussing the paper Mr. George C. Foote of the Witherbee, Sherman Co. said that 25 per cent ore is being worked successfully at Mineville, and that an even break financially could be expected on 20 per cent ore. Low-phosphorus ores are growing scarcer, and it is interesting to note that the phosphorus in the crude magnetite is reduced to one-half by magnetic concentration. The 0.02 per cent ore at Mineville is concentrated to 0.01 per cent P and 60 per cent Fe.

Mr. Birkinbine said that it was not to be inferred from the paper that all ores could be concentrated for 11 cents per ton. A coarse ore easily granulated can be concentrated. For the past year he has studied the lean magnetites in the East. In one section of Pennsylvania he found five different ranges of ore, showing the great diversity in the character of the ore. A great deal of experimentation is necessary before deciding on a process of ore treatment.

A paper on "Rock Crushing at McGill University" was read by JOHN W. BELL. It describes a series of tests on rock crushing, showing that Rittinger's law gives a better criterion for different machines as to crushing efficiency than does Kick's law.

A paper on "Counter-Current Decantation" was presented by LUTHER B. EAMES. This paper was published in full in our issue of Jan. 15, 1917, page 94. It was discussed by J. V. N. DORR.

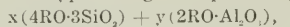
"The Function of Alumina in Slags" was the subject of a paper by CARL HENRICH, who dealt with the matter from the standpoint of the iron blast-furnace engineer. His chief conclusions were:

In slags containing larger quantities of alumina, the alumina should be considered as an acid, replacing silica, and not as a base.

The higher the percentage of alumina, the nearer the slag should approach a "singulo-silicaluminate," i.e., the nearer the oxygen ratio of the bases should come to the combined oxygen of the silica and alumina.

An increase in magnesia calls for a higher percentage of bases, while absences of magnesia, and a pure limestone as a flux, will permit an approach to a "bi-silicaluminate" slag.

The safe way will be to start with a "sesqui-siliculate" as the type of slag to be produced,



which is approximately the slag actually, successfully and involuntarily.

In the discussion Mr. A. S. Dwight said he did not think that Al_2O_3 should be considered either as an acid or as a base, but should be neutral, inert, non-combining, dissolving in the slag itself. In actual practice this was tried at El Paso in a lead furnace with good results, figuring alumina, fluorspar, and zinc oxide as inert constituents. He thinks experiments should be made on a large scale as well as in the laboratory in order to solve this question.

Mr. E. P. Mathewson said that in Colorado, running on high alumina ores from Cripple Creek, he left the alumina out of the calculations and got excellent results with a freely running slag. When calculating the alumina in, trouble was experienced.

Mr. Boggs said he had worked on slags where the $\text{MgO} + \text{Al}_2\text{O}_3$ ran up to 18 per cent in making a 55 per cent Cu matte. He found that by neglecting the Al_2O_3 below 10 per cent good results were obtained, but above that the slag would not run.

Prof. J. W. Richards said the title of the paper was too broad, as its subject matter referred only to alumina in iron blast furnace slags. Hence the qualifications do not apply to lead or copper furnaces. Mr. DWIGHT replied that the temperature in the lead blast furnace may not be high enough to form silicates of Al_2O_3 and Zn as in iron furnaces.

"The Viscosity of Blast Furnace Slags" was discussed in a paper by Dr. ALEX. L. FEILD of the Bureau of Mines. The paper described a method of measuring the viscosity. In the discussion W. McA. Johnson said he thought the paper too theoretical. Dr. Feild said no attempt had been made yet to make a works instrument, but that would come later. Prof. R. H. Richards, Prof. J. W. Richards, George K. Burgess and Mr. Guess also discussed the paper.

A paper on "Matte Granulation at Herculeum, Mo.," by S. P. LINDAU and H. B. SMITH was read for the authors by Arthur S. Dwight.

Silica Refractories

In the Tuesday morning session, over which Prof. HEINRICH RIES presided, an interesting paper on silica refractories by J. SPOTTS McDOWELL of the Harbison-Walker Refractories Co. was presented describing a series of elaborate studies on the silica refractories. Some interesting lantern slides were shown describing the main features of the work. A fuller account of the paper is reserved for a future issue.

In the discussion Prof. J. W. Richards said that there are probably twenty different circumstances under which brick are used and the scientific study is extremely valuable. He called attention to the electrical conductivity, which was not mentioned in the paper. Mr. Henry D. Hibbard said he had had experience with silica brick in melting steel where pieces of the brick broke off instead of dripping down as customary. He thought insufficient mixing of the raw materials entering the brick might cause this failure.

Iron Blast Furnace Practice

Four papers were presented at the Tuesday afternoon session on iron blast-furnace practice, at which Prof. JOSEPH W. RICHARDS presided.

Two papers were presented by Messrs. LINN BRADLEY, H. D. EGBERT and W. W. STRONG of the Research Corporation, New York City. The first paper discussed the advantages of using a gas of higher flame tempera-

ture with improved stove design, together with the electrical method of cleaning the gas. The authors' second paper presented suggestions for the construction of hot-blast stoves along the lines discussed in their first paper. An abstract of the second paper will be found on page 283 of this issue. In the discussion Mr. F. H. Willcox said that dry-hot cleaning will probably be used to a large extent in the future when the gas is to be used under boilers. Mr. Breyer of the N. J. Zinc Company said they had considerable success with Tyson washers, scrubbing the gas which goes to boilers and stoves. The gas contains zinc oxide fume. He thought asbestos bags would probably be good when the hot gases are to be used after passing through the bags. He said that Messrs. Frazer and Chalmers of England are developing the asbestos bag-house system for hot gases, and have made several installations.

A paper on "Calculations with Reference to the Use of Carbon in Modern American Blast Furnaces" was presented by HENRY PHELPS HOWLAND. The paper was read by title. A communicated discussion by Professor Mathesius of Charlottenburg was read by the chairman, who also discussed the paper.

The paper on "Potash as a By-product from the Blast Furnace" by R. J. WYSOR was the subject of a long abstract in our Feb. 15 issue, page 205. Mr. Wysor showed some samples of the products from various locations at the Bethlehem Steel Company's plant at Bethlehem. The paper was discussed by Dr. Unger of the Carnegie Steel Company, who said they had made investigations of potash at many points. They used Lake Superior ore, Ohio and Pennsylvania limestone and Pennsylvania coke. This is somewhat different from the burden of the Eastern furnaces. The potash which they found was either insoluble or only one-third water soluble, and not enough to pay for recovery. They are at present making experiments around furnaces making ferro-manganese and ferro-silicon. The paper was also discussed by Messrs. Riddel, Breyer, Huston and Roush.

Flotation Discussion

The flotation session on Tuesday afternoon was presided over by EDWARD P. MATHEWSON. There was only one paper on the program entitled "Notes on Flotation, 1917," by J. M. CALLOW of Salt Lake City. Mr. Callow was in New York, but unable to attend the meeting, being engaged in a patent suit. His paper was therefore presented by Mr. H. A. Megraw who dealt especially with the notes on the Magma Sulphide Filming Plant. We herewith give this part of Mr. Callow's paper practically in full:

MAGMA SULPHIDE FILMING PLANT

The process in use in this plant is covered by Schwarz's U. S. patent 807,501, which is the first disclosure of the use of a soluble sulphide for converting an oxide of a metal into a superficial sulphide, and afterward recovering it by a flotation process.

Our earliest experiments were made with H_2S gas as the filming agent. A plant of 25 tons daily capacity was built. In this the gas was applied to the pulp by introducing it into the bottom of an open tank, having a mixing agitator. The results were encouraging, but the consumption of gas prohibitive—as much as 8 or 10 lb. per ton. The ore treated was the tailings of the Magma sulphide mill, which at that time carried considerable oxides. Occasional recoveries of 60 per cent (of the total copper) were made, but the results were erratic owing to the difficulty of getting uniform filming of the pulp with this method of applying gas. Then followed an interval of several months when we used sodium sulphide, calcium sulphide, and calcium sulphohydrate in an endeavor to avoid the use of gas, on the assumption that it was objectionable owing to the danger of its poisoning the surrounding atmosphere. This was true when attempting to use it in an open tank, much of it being lost in the atmosphere. During this time a number of

theories were advanced, exploited, and abandoned. One of these was that natural and artificial sulphides could not be floated together, and that H_2S interfered with the flotation of the natural sulphides. Our experience now is that H_2S , in the proper quantity really promotes flotation of natural sulphides in company with the filmed oxides, and also that the nature of the oil, and whether the oiling is done before or after filming, and whichever plan is followed is merely a matter of convenience.

In treating Magma sulphide tails, in which the principal losses were sulphides, the introduction of the gas not only filmed the oxides present, a goodly percentage of which was recovered, but it also raised an entirely new crop of refractory sulphides. An all-sulphide sample of regular Magma ore was tested with and without H₂S.

The commercial plant was shut down and we again reverted to laboratory work, which resulted in our adherence to H_2S in preference to any other agent on this particular ore, and also to a complete change in our method of applying it. The plant was reconstructed, crushing machinery and additional cells added in accordance with the flow sheet shown in Fig. 1, for the purpose of treating Magma oxidized ores on a commercial scale.

which interferes with flotation, and can always be identified by its eye-burning properties. This is in a measure overcome by careful scrubbing, sulphur being precipitated in the scrubbers with free H_2S liberated.

The California crude oil has the following fractional analysis:

Specific gravity 0.9311 or 20.36 Bé. at 15 deg. C.

Flash point—open dish—108 deg. C.

Fractionation:

Temperatures	Distillate, C.c.
100 deg. C.—150 deg. C.	1.2
150 deg. C.—175 deg. C.	1.6
175 deg. C.—200 deg. C.	3.6
200 deg. C.—225 deg. C.	9.6
225 deg. C.—250 deg. C.	22.0
250 deg. C.—275 deg. C.	30.8
275 deg. C.—300 deg. C.	25.2

Free gas in a pulp is fatal to flotation, hence the use of the blowing cell at the head of the first flotation cell. Experiments indicate that heating the pulp slightly before gasing is beneficial.

The cost of manufacturing the gas by this method will, of course, vary greatly according to local conditions. Those at Magna are abnormal. Sulphur is costing nearly 3 c. to-day, and oil nearly 1 c. per pound, f. o. b. Superior, and costs on a basis of 30 tons per day, and maximum of 3 lb. per ton, stand as follows: 90 lb. of sulphur at 2.74 c., \$2.51; 225 lb. of oil at 0.914 c., \$2.16; total, \$4.77 = 15.25 c. per ton, or approximately 5 c. per ton for each pound of sulphur per ton required by the ore.

On Magma sulphide tails, the gas consumption varies from $\frac{1}{2}$ to $1\frac{1}{2}$ lb. sulphur per ton. On strictly carbonate ore, assaying 3 or 4 per cent copper, 3 lb. is an average figure, and on the latest test with a mixed carbonate and silicate ore, assaying from 4 to 5 per cent copper, 2 lb. of sulphur per ton. The fuel required for heating the retort is almost negligible. There are no cost figures, since so far we have been burning scrap lumber left over from construction. The labor item is unduly heavy since the retort is situated some 600 ft. away, and one man has to be held in reserve for the purpose. He could as easily make gas on one shift for 500 tons per day. With

TABLE 1.—COST

1000 lb. of sulphur at \$45 per ton	
= 2.25 c. per lb.	= \$22.50
2500 lb. of oil at \$1.75 per bbl.	
= 0.436 c. per lb.	= 11.00
1 man at \$4	= 4.00
Extra fuel for heating retort and sundry repairs	= 2.50
	Per day \$40.00

sulphur and oil at moderate prices on a 500-ton scale, using 2 lb. of sulphur per ton, my estimate of total gas cost is as given in Table I.

Thus the probable cost is 8 c. per ton of ore, or 4 c. per ton for each pound of sulphur required for the ore.

Other methods were tried—one using powdered coal in a separate retort instead of the oil mixture, and another in which the oil instead of being mixed with the sulphur was dripped into the sulphur retort with a force feed lubricator. The usual iron matte and sulphuric acid method

TABLE II.—POWER REQUIREMENTS

1	6-ft. by 16-in. Hardinge ball mill.....	35 hp.
1	8 ft. by 14½ Root blower, No. 1 (400 cu. ft. at 5 lb.)	
1	7 by 14 Dodge crusher (1 shift only).....	
1	2-in. centrifugal gasing pump.....	20 hp.
1	4-in. diaphragm pump.....	
1	10-in. belt drag classifier.....	
1	Oil feeder.....	
1	Oil feeder.....	
		55 hp.

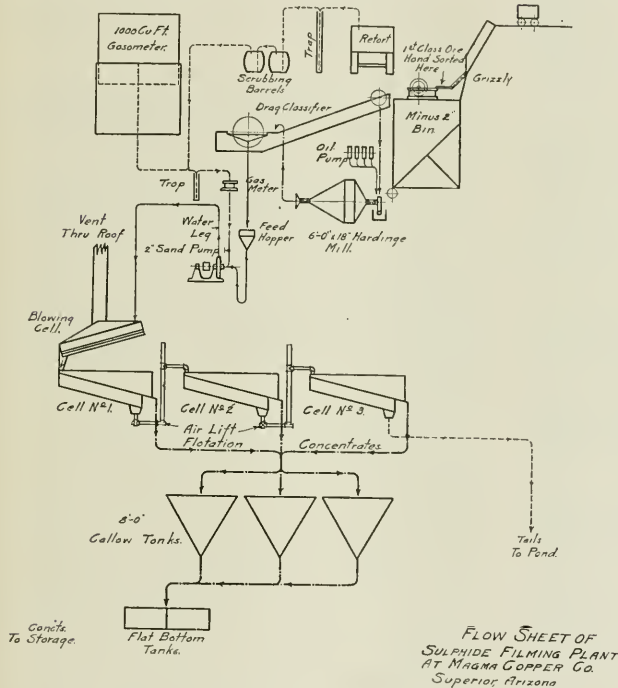


FIG. 1—FLOW SHEET MAGMA SULPHIDE FILMING PLANT

The gasing method used at present introduces the gas into the suction of a centrifugal pump in the manner indicated in the flow sheet. This has proved effective, greatly reducing the gas consumption, giving more uniform recoveries, and has removed all danger from the poisoning of the atmosphere; in fact, the commercial results now being obtained date from the first use of this expedient.

MANUFACTURE OF H₂S GAS

The present method of making H₂S gas is to heat sulphur and oil in a retort. Various proportions of sulphur and oil have been tried, our present proportions being 1 of sulphur to 2½ of oil. The temperature in the retort is kept at a uniform 300 deg. C. At times the making of gas has given considerable trouble, owing almost entirely to changes from time to time in the quality of the oil used. Satisfactory results have been obtained at all times with California crude oil, but Texas oil always gives trouble, making a gas containing what we believe to be hydrogen persulphide.

was also tried but none of these methods had anything to recommend them over the one adopted. Iron matte was never seriously considered on account of the recent high price of acid.

The flow sheet given in Fig. 1 is self-explanatory: The 6-ft. by 16-in. Hardinge ball mill has a capacity of 35 tons per day when loaded with balls requiring 35 hp., or 45 tons per day when loaded up to 50 hp. crushing from crusher run to 83 per cent — 150 mesh.

The power requirements are distributed as stated in Table II.

This is the equivalent of 37.6 hp.-hr. per ton, = 28 kw.-hr. per ton.

The plant is operated by four men for the three shifts, the extra man on day shift crushing the ore and hand sorting out any first-class ore there may be at the same time.

A general discussion on flotation followed. It was kept alive and rendered quite interesting enough through the energetic efforts of the chairman, Mr. Mathewson.

It was opened by Dr. Rudolf Gahl, whose long discussion was sent with Arizona enterprise by telegram and who answered some criticisms of his own former paper by Mr. Callow and in turn criticized some points of Mr. Callow's paper, particularly relating to the comparison of the Callow flotation machine and the Inspiration flotation machine. Dr. Gahl's long telegram was read in full by Mr. Robinson.

Mr. G. D. Van Arsdale expressed the opinion that ores should be divided for flotation into three classes; first, those requiring acidity of pulp; second, those requiring alkalinity of pulp, and, third, those requiring neutrality of pulp, and that there seems no doubt that this varying action is to be referred to the influence of the constituents of the gangue. He also brought out another important practical point, namely, the composition of mill waters and the effect of dissolved salts on flotation.

Mr. John V. N. Dorr read a discussion by Mr. E. R. Ramsey, relating to the handling of flotation concentrates and the use of the Dorr thickener and tray thickener.

Professor E. E. Free spoke on the theory of the flotation process and proposed the hypothesis that adsorbed films, formed previously to the application of the flotation oils, might explain many anomalies of flotation practice.

Professor J. W. Bell asked whether that would explain the necessity of using acid in many particular cases. Professor Free answered that no generalization of his hypothesis seems possible at present. Every case of adsorption has to stand on its own feet.

Mr. H. W. Dubois discussed flotation litigation. He asked: How can even the best courts as now constituted pass on such highly technical problems? Is it not like playing baseball with an umpire who has never seen the game? Does flotation really depend on the use of such a very small quantity of oil? Is there really a critical point in the amount of oil which makes the process effective? From his experience he concludes that there is no such critical point for certain classes of ore, though there may be for others. For certain classes of ore 2 or 3 or even 25 per cent. of oil will give as good results as less than 1 per cent of oil, and the use of the latter amount is merely a matter of economy.

Mr. G. D. Van Arsdale said he had never found a critical point nor did he see any reason for its existence. But certain apparatus may be better for certain amounts of oil.

Mr. J. V. N. Dorr referred to two Western companies which use more than 1 per cent of oil.

Mr. Mathewson told how in a particular case a flotation expert came and experimented for some weeks without conclusive results; when a little sulphuric acid was used it worked fine. Why? He also stated that excel-

lent results had been produced with more than 1 per cent of oil and that the use of less than 1 per cent of oil was simply a question of economy.

Professor R. H. Richards referred to flotation as a friend, not a rival of gravity concentration.

Mr. Dubois referred to bornite ore, which, according to Hoover, was difficult to float. But he found that acid helps, and his experiments showed that CO₂ bubbles attached themselves while the ordinary bubbles would not. Hence this is not the ordinary acid effect. Dr. Bell spoke of some similar experiments. Mr. H. W. Hardinge told a good story; Mr. Calbraith referred to mining as the fundamental industry, and after Mr. Dubois had pointed out that Japan had passed a law not to allow any flotation patents and that the fundamental U. S. patents for flotation had not been granted in Germany, the meeting adjourned.

Manufacture of Iron and Steel

Mr. Henry D. Hibbard presided at the Wednesday morning session devoted to the manufacture of iron and steel.

"The Seasoning of Castings" was the subject of a paper by RICHARD MOLDENKE. An abstract of this paper will be given in our next issue. Mr. Outerbridge, Jr., of Philadelphia gave an interesting discussion of this paper.

A paper on "The Significance of Manganese in American Steel Metallurgy" was read by F. W. WILLCOX.

A paper on "Roll Scale as a Factor in the Bessemer Process," by A. PATTON and F. N. SPELLER, was read by Mr. Speller.

A paper on "Temperature Measurements in Bessemer and Open-Hearth Practice" was read by GEORGE K. BURGESS.

A paper on "The Manufacture of Weldless Steel Tires for Locomotive and Car Wheels" was read by GUILLIAEM AERTSEN.

Metallography and Heat-Treatment of Steel

This session was held on Wednesday afternoon, ALBERT SAUVEUR presiding. The following papers were presented:

"Erosion of Guns—The Hardening of the Surface," Henry Fay.

"Notes on the Heat Treatment of High-Speed Steel Tools," A. E. Bellis and T. W. Hardy.

"Effect of Time in Reheating Hardened Steel Below the Critical Range," C. R. Hayward and S. S. Raymond.

"The Effect of Sulphur on Low-Carbon Steel," Carle R. Raymond.

"A Method for Distinguishing Sulphides from Oxides in the Metallography of Steel," George F. Comstock.

Professor Sauveur opened the discussion of Professor Fay's paper. He said that all the conditions necessary for case hardening were present in gun firing and that it should be taken into account. Mr. Hiram Maxim said a temperature of 4000 deg. Fahr. to 4500 deg. Fahr., was produced in a gun using nitrocellulose. Temperatures up to 6500 deg. Fahr., are obtained from mixtures of nitrocellulose and nitroglycerin. The products of combustion are under a pressure of 35,000 lb. per square inch. The caliber of the gun is increased 0.001 inch at every shot. Mr. Lawrence Addicks thought the thermal conductivity should be studied, as some steels have lower conductivity than others. Mr. Maxim didn't think there was time enough for much heat conductivity; Professor Richards said that by using alloys of iron with metals such as tungsten, boron, titanium, etc., which give a lower vapor tension, the life of the gun ought to be prolonged. Professor Fay replied to several questions.

Nitrate Industry in Chile

By I. Berkwood Hobsbawn

So much attention has been drawn in recent years to the rapidly approaching death of the Chilean nitrate industry that it seems very much like "flogging a dead horse" to draw the attention of chemists, metallurgists and chemical engineers to it. In spite of this approaching "calamity," a description of this industry and an indication of its "re-birth" will not come amiss during a period such as this, when the prime output of the industry is of such vital importance.

Nitrate of soda, the substance which lends itself so equally to man's needs for both his peaceful and his war-like arts, is met with in nature in enormous quantities in the arid zone between the slopes of the Andes in the north of Chile and the foothills to the sea. This tableland, varying in altitude from 3000 to 7000 ft. above sea level, has been sufficiently described from time to time to need no further location or description here, but for years it has been the center of the production of nitrate of soda for the world's fertilizer needs.

Since its use was brought to the notice of the world in 1809 by Taddeo Haenke, a German domiciled in Bolivia, the export of nitrate of soda has exceeded a total of 53,000,000 long tons, and the present output is in the neighborhood of 2,500,000 to 3,000,000 long tons per annum. It will be agreed on this basis that the Chilean nitrate industry is one of very huge proportions, and at the same time, it must be asserted, that apparently little is known about it by the world in general in proportion to its importance or size.

As the attention of this country is being drawn very markedly to the value of nitrate of soda, both as a fertilizer and for other less peaceful purposes, and as the so-called exhaustion of the deposits in Chile, due in 1921 according to the "authorities," has been indefinitely postponed, it is very opportune to describe for the American readers interested in this particular product how nitrate of soda is obtained from the crude deposits and, further, to indicate how American progress in other directions and industries is being used to attempt the modernization of the methods in use in Chile, and to reorganize completely the means of procuring the refining of so useful a product. It would perhaps be as well officially to refute once and for all the statement so widely circulated in this country and in Europe that the nitrate deposits in Chile are very rapidly becoming exhausted.

The official report recorded below is that of Mr. Francisco J. Castillo (the inspector general of the nitrate deposits for the Chilean Government), which was issued in November, 1913, by the Chilean Nitrate Committee of London, England, under the auspices of the Chilean Embassy in that country.

Nitrate of Soda Deposits in Chile

"According to the latest official report presented to the Chilean Government by Mr. Francisco J. Castillo, the inspector general of the nitrate deposits, the zone of nitrate-bearing grounds comprises 200,000 sq. km., of which so far only 5811 sq. km., that is to say, less than 3 per cent, are examined and their contents ascertained by excavation and test holes. These 5811 sq. km. belong to existing companies and private firms, and in part are still in the hands of the Chilean Government. The calculated contents of this 5811 sq. km. are 290,300,000 tons of nitrate of soda, of which up to the present 45,000,000 tons (1912) have been extracted and exported, leaving in the examined part of the area 245,300,000 tons of nitrate of soda, equal at the present

rate of production to a supply for a further hundred years. As the unexplored part is some thirty-four times larger than the explored grounds, it is safe to estimate that it contains altogether at least an equal quantity of nitrate of soda, and consequently the nitrate zone in Chile can certainly provide nitrate of soda for another 200 years at the present rate of production.

"The quantity of nitrate of soda in the examined grounds is subdivided as follows:

In the province of Tarapaca there remains.....	35,000,000 tons
In the Tocopilla District there remains.....	28,000,000 tons
In the Antofagasta (Central Dist.) there remains.....	32,000,000 tons
In the Antofagasta (Aguas Blancas) there remains.....	48,000,000 tons
In Chanaral and Copiapo there remains.....	8,300,000 tons
A total of	245,300,000 tons

"The inspector general of nitrate grounds in his report to the Chilean Government has arrived at these figures in the following way:

"In these examined grounds no raw material containing less than 11 per cent nitrate of soda has been taken into consideration, nor grounds where the thickness of the layer of raw material is less than 1 ft., except in the case of raw material of at least 25 per cent of nitrate of soda, where the thickness of 8 in. and above has been included.

"The superficial area of each portion of ground examined has been divided by the total number of test holes made in order to arrive at the area applicable to each test hole, and this consequently determines the total nitrate-bearing area.

"From this theoretical quantity of pure nitrate of soda resulting from the above operations, a reduction of 40 per cent has been made in order to provide for losses in extraction, manufacture, errors of calculation, etc. Of raw material of a lower grade vast quantities remain which have been excluded from these calculations because they cannot be profitably extracted under the present system of work, but as improvements are being constantly made there is every reason to assume that even this low-grade material will be worked when the richer qualities are exhausted."

These statements, therefore, conclusively show that there is no fear of the Chilean nitrate deposits being exhausted for 200 years on the present basis of output and present efficiency of plant.

Taking into consideration that during the last four years an enormous impetus has been given to development work in Chile, through one cause or another, and that many workers are engaged in attempting to apply the principles found successful in industries in other countries, it will be agreed that some measure of success attending these developments would not only increase the estimated 200 years in proportion to the increased efficiency which these new processes would give, but would also bring into consideration the material of less than 11 per cent, which at present is not included, by making it amenable to treatment.

This point does not need very much laboring for mining engineers to appreciate the huge quantities of material that will be brought into value if the process is able to use up anything above 5 per cent material. At the present day it is not only found advisable not to include 11 per cent and under in the estimated nitrate contents of the grounds, but more, in working these grounds, it is often impossible to take into the works material of 14 per cent and lower, and necessarily the raw material has to be hand-selected. In fact the limitations imposed upon the mining of nitrate of soda by the poor efficiency of the refining plants are such that where an average of 20-22 per cent nitrate is required for the refining plant very little material of less than 14 per cent can be used with richer material to make up the required average.

Under these circumstances, if a description of the actual work of the nitrate industry is given and an outline of the methods in use is drawn, subsequently followed by an indication of the direction in which it is hoped that higher efficiency shall be gained, it will then be appreciated what would be really effected by these changes, not only in regard to the methods of mining involved, but also to the operation of the whole of the industry itself.

The methods of refining nitrate of soda have been variously referred to as crude and primitive, but whereas these terms might well be applied to the actual methods of lixiviation and mining, the mechanical means for carrying out such do not come under these headings; in fact, were it not for the development of the mechanical side of the operations, it is very doubtful whether the industry could have been carried on to any profitable extent with the lower-grade material now in use.

In modern works the handling of the raw material and the generation of power for that purpose and for the disposal of the refuse has been developed on very modern lines. The methods of treatment of the raw material, however, do not yield a high efficiency for various reasons, and it is because of this low efficiency in the works that methods of mining of the raw material are very much restricted; in fact, take the average efficiency of the process as 50 per cent, and the refuse over all, accounting for 10 per cent nitrate, the minimum contents of nitrate in the raw material cannot, except in special instances, be less than 20 per cent. Twenty to 22 per cent is the general average of the material sent to the works for refining, and in order to gain this average ley of material from the grounds it is necessary to resort to hand-selection, such selection to a large extent depending upon the personal experience of the miner controlled by the general analysis performed in the factory. In this way the mining is costly and the percentage of nitrate taken out as raw material, out of the total of the deposits, comparatively low.

Raw nitrate-bearing materials are known locally under names which are supposed to denote the physical state and richness of quality. Caliche and Costra are the names mostly used, the former generally being the richer and purer, the latter being the poorer and the more impure. There is, however, no great consequence to be attached to these names at the present, as they are very often used interchangeably in different localities, but the name Caliche was originally applied to the kind of material containing very little insoluble matter and consisting essentially of nitrate of soda and common salt.

Caliche, however, may be considered to be the richer underburden, where costra is the poorer layer above it, it, in its turn, being usually overburdened by a layer of barren material.

The thickness of the deposits of both caliche and costra is variable, and at the same time both caliche and costra vary very much in physical structure, sometimes being hard and compact, sometimes soft and friable, and according to this nature can be sent to the works for refining with a nitrate content of 14 per cent and upwards. There are, however, qualities of costra which, even with contents of 22 and 25 per cent (and these might very well be called caliches), cannot be successfully treated by the processes in use to-day, because their compactness and imperviousness to water allows them to pass through the lixiviation process practically unaltered.

It is quite impossible to give a clearly defined description of what is costra and what is caliche, or to state any general rules as to which type of material should

or should not go into the works for refining. These factors are local and depend to a large extent upon the judgment of the manager of the works and the foreman and miners who are employed in removing the raw material from the grounds. For example, some types of stoney raw material with 10 per cent nitrate content may yield up all their nitrate to the attaching solutions, while other varieties of 15 per cent may only yield 4 per cent, or even nothing.

What is aimed at in the mining of nitrate-bearing raw materials is to get an average material as high in ley as possible, which will prove most amenable to the process of refining, yielding up to the solutions used for its lixiviation sufficiently high a proportion of its nitrate content while not causing too high a production of insoluble fines in the leaching tanks. This can only be attained by selection of material based on an extensive use of the personal equation.

It will be seen from this that so long as the present methods of refining are used, so long will the development of the mining of nitrate of soda on modern lines be delayed, and as a corollary so long will restrictions be placed upon the quantity of material which can be extracted from the grounds themselves.

The actual methods of mining of this raw material need not be gone into in detail in an article of this nature, but it might be sufficient to indicate that with the restrictions which have been referred to above there is very little possibility of being able to operate to advantage the mechanical methods of mining, which would so reduce costs of operation as has been found in other mining industries. It is even doubtful as to whether the modern methods of mining could ever be easily adopted in the Chilean fields in their entirety, assuming it were possible to treat an average grade of material of about 5 per cent. The main reason for this is the irregularity of the deposits, both as regards distribution and thickness.

The miners work on piecework, being paid a price agreed on for every cartload of suitable material passed to the works. The hand-selected material is loaded into carts holding from $2\frac{1}{4}$ to $2\frac{1}{2}$ short tons, the lumps weighing anything from 25 to 50 lb. It is kept as free from dust and barren overburden as possible, although a fair proportion of useless "smalls" is often brought in with the selected material. An average analysis of 22 per cent caliche used in the process might be taken as below:

Nitrate as nitrate of soda.....	22 per cent
Chloride as chloride of soda.....	30 per cent
Sulphate as sulphate of soda.....	4 per cent
Insoluble matter	54 per cent
100 per cent	

The nitrate is present as nitrate of soda, potash, lime, magnesia, though all of these bases are not necessarily always present.

Chlorine is also present allied with traces of these other bases, and sulphates of lime and magnesia are also present in varying quantities.

Method Employed in the Refining of Chile Saltpetre from the Raw Materials

In the most modern of the Chilean works the methods adopted to-day actually differ very little from those used thirty years ago. The principle on which the method is based depends upon the fact that sodium chloride is not sufficiently soluble in concentrated boiling solutions of nitrate of soda to contaminate the latter seriously when the solution is cooled in order to crystallize it. That is to say, that a saturated solution of salt, when warmed up and subsequently raised to the maximum boiling point in the presence of nitrate of

soda will take up the latter and deposit the salt to such a point that the nitrate of soda can be crystallized from the solution obtained by cooling, and the crystals obtained will be commercially free from sodium chloride contamination.

The raw material is passed through jaw crushers of the Blake-Marsden type, and the crushed material is lifted to the boiling tanks either by belt conveyor, bottom emptying car and hoist (electrical or hydraulic), or drawn up an inclined plane in a side tipping or bottom emptying car. Where a belt conveyor is used the actual distribution of the material to the tanks is done by means of the cars above referred to or, as in some cases, by belt distribution. The tanks, 32 ft. x 9 ft. x 8 ft., provided with false bottom 9 in. to 12 in. from the true bottom, three doors in the bottom for discharging ripio (refuse), steam coils for heating purposes and connections for transferring liquors and running off finished liquor and washes, are loaded with the crushed material. The size of crushing is varied, according to the hardness of the raw product, from 3 in. for the softest to $\frac{3}{4}$ in. for the hardest types.

The charge weighs anything from 60 to 70 tons. It is now leached in stages, usually four or five operations being necessary. The first is with the strongest liquor available, which is obtained from the tank immediately behind and whose origin will be seen from the description of the complete cycle, and this is carried out at the highest temperature to be obtained, the boiling being continued for a period of from two to three hours, according to the grade of material under treatment.

At the expiration of this period the boiling liquor, which is now strong enough to send to the crystallizing tanks, is slowly run off from a point about half way up the tank, the level of the liquor in the tank being maintained by feeding with the next strongest liquor from the tank behind. The "caldo," as it is called, is run off slowly for a period of from two to three hours, boiling and feeding being maintained all the time, and the flow is only stopped when the liquor has decreased in strength, due to the weaker feed not being able to be strengthened quickly enough in the boiling tank which is under review.

The feed liquor is intended to *replace* the caldo running off, but in actual practice it mixes with it and thus limits the efficiency of the operation. When the flow of caldo is stopped, "cut," the feeding liquor is stopped and the liquor in this tank is transferred by pump or by leveling action (or both) to the next tank forward, which contains fresh caliche, and the preparation of caldo proceeds anew from this fresh caliche. The tank which has now been boiled once is filled up with liquor from the tank behind it (this liquor is the result of the second boiling of this material in this tank) together with mother liquor from the crystallizing tanks and boiled for a further period during which the fresh caliche in the tank forward is being boiled for the first time with the liquor it has received from the tank under description, while the tanks further back are receiving their third, fourth and fifth treatment or washing. In this way the caliche is successively leached with four or five liquors in a cycle of operations, the first two leachings being at the boiling point, the third and fourth at lower temperatures, the final wash water being cold water. The whole operation takes eighteen to twenty hours per tank. The spent caliche, after draining, is discharged into wagons and deposited on the dump tips, the drained liquor being passed forward in the system in due course.

The strong liquor (caldo) is run into settling tanks, where it is clarified sometimes by "time" settling only,

sometimes with the aid of flour, dung, etc., and the clear liquor is decanted off into open troughs, through which it is conducted to the crystallizing tanks.

These crystallizing tanks are 15 ft. x 15 ft. x 2 ft. 6 in. x 3 ft., sloping to one side, and an outfit of these tanks is enough to allow of sufficient being filled each day and occupied for twelve to thirteen days, with a two days' supply in reserve. Thus a works filling ten tanks a day will require about 150 tanks for its equipment.

The cooling is done by exposure to atmosphere, and takes eight to eleven days, at the expiration of which the plugs, which are fitted in the bottom, are withdrawn, and the mother liquor drained off to open troughs below, which conduct it to the mother liquor stock tank. From here it is sent back to the system as above. The crystalline deposit in the tanks is equal to about 25-35 lbs. nitrate from 1 cu. ft. caldo, and for every 1 lb. nitrate deposited as crystal about 0.5 lb. returns to the system as mother liquor. The nitrate after draining contains 8 to 10 per cent liquor, and the crystals are heaped on the drying floors (into which some of the mother liquor drains and is lost), where the heaps are periodically raked over in order to expose more surface, and by atmospheric evaporation and draining over a period of a month the crystals are reduced to 2 to 3 per cent moisture contents, after which the lumps are broken down with wooden mallets and the nitrate filled into sacks, each holding about 200 lb., for entrainment to port.

In 1911 an English nitrate company began the construction of a new refining works (Oficina), which was designed for an output of 90,000 qtl. nitrate per month from material containing 25 per cent of nitrate of soda.

In this works the whole of the power for crushing and distribution of crushed material and for pumps was provided by a central electrical generating station containing two 200-hp. Diesel engines direct coupled to two three-phase alternators of Siemens Brothers. For the transmission of power to the wells and outlying places step-up transformers are used and the current transmitted on bare copper aerial lines.

The steam for process work was generated by oil-fuel-fired Lancashire boilers, of which five were installed (30 ft. x 7 ft. 8 in.).

The material was crushed in Blake-Marsden crushers, driven electrically, five of these said crushers being installed (24 in. x 18 in.).

The crushed material was elevated to the boiling-tank stage by belt conveyors and distributed by belt to the tanks for loading. There are eighteen boiling tanks, each 34 ft. x 7 ft. 6 in. x 8 ft. 6 in., provided with false bottoms 1 in. above true bottom, fitted with the necessary connections for transference of liquors and three ripio discharge doors for discharging the spent caliche. The latter is drawn to the dump tip side-tipping wagons drawn by petrol locomotives. The plant is equipped with 154 crystallizing tanks, each 18 ft. x 18 ft. x 3 ft. 6 in., sloping to 3 ft., the whole of these mounted on a substantial steel structure. The raw caliche is brought into the works by a light railway, 2-ft. 6-in. gage, 35-lb. rails spiked being used, drawn by locomotives constructed by North British Locomotive Company, Limited.

The mileage of railway in the grounds is $2\frac{1}{2}$ miles, and the loading stations are fed by carts and mules from the actual mining localities.

The water supply is derived from wells, as is usual in these districts, the power for pumping being supplied from the central station.

The plant is equipped with a very complete engineering workshop fully capable of dealing with all necessary

repairs for the efficient upkeep of so large a mechanical installation. It is also equipped with a small foundry for both brass and iron.

A description of one month's working will show what results are obtained in actual operation.

During twenty-nine days worked in one particular month there were brought in 12,484 cartloads of raw material.

Estimated weight of cartload 41 Spanish quintals (101.2 lb.), fifteen carts were employed in feeding the loading stations, each making about twenty-eight trips per day. Two locomotives and sixty-five side-tip wagons were used to transfer the material from the loading stations to the treatment plant.

The raw material averaged 21.89 per cent nitrate, and the total treated 499,544 Spanish quintals were divided into 350 charges (tank loads) of about 1430 qtl. each, and the yield showed, on the figures taken, an efficiency of 56.4 per cent. The figures are as follows:

Total caliche 499,544 qtls. at 21.89 per cent nitrate equals 109,356 qtls. nitrate	
produced 65,000 qtls. of 95 per cent nitrate equals 61,750 qtls. nitrate	
LOSSES	
In ripio 400,644 qtls. (dry weight, estimated) at 5.04%	20,192.45
In Borra 33,900 qtls. at 1745% nitrate.	5,915.55
Unaccounted for	21,492.00
	47,600.00

A recovery of 56.4 per cent of the nitrate contained was effected from raw material of about 22 per cent.

For each quintal of petroleum consumed 7.98 qtl. of nitrate were extracted, or in coal equivalent (taking the heat efficiency oil to coal as 18 to 12) 1 qtl. of coal produced 5.32 of nitrate.

With such a material as caliche this countercurrent system does not give most efficient results for a variety of reasons, chief among which are:

1. All liquors passing forward are saturated solutions of salt and nitrate at their temperature, and as they take up more nitrate with rise in temperature they deposit salt. When this salt is deposited around the lumps of caliche, it tends to act as a protective coating against the action of the succeeding liquors, which are themselves, as shown, saturated with salt.

2. The circulation in the tanks is very poor, for the tendency of the solid is to pack close during leaching, and hence the liquors passing through the charge will endeavor to take the line of least resistance. Under these circumstances, channels are liable to be formed in the solid, thus permitting certain of the contents of the tank to escape lixiviation altogether.

3. The solid on yielding up its nitrate to the attacking solutions loses the binding agent which has kept it in lump form, and the lumps fall apart in the form of sand, stones and clay, which were bound together in solid form by the crystals of soluble nitrate, etc.

The result of this is that it becomes exceedingly difficult to drain off the liquor from the solid, and thus every successive wash becomes a dilution of stronger liquor contained by the weaker following one, and as the final draining is equally poor, the net result is to dispose of the refuse containing not only undissolved nitrate, but a very high proportion of nitrate liquor containing.

During the course of the operations the space referred to between the true and the false bottoms becomes filled with the finest of the particles of the insoluble matter, which have found their way through the perforations in the false bottom. This is known as borra. This space was originally intended for the reception of this fine sandy matter, in order to keep the bulk of the charge free from it, but it is not sufficient nor can it be made sufficient to take the whole of the

fine matter produced during the disintegration of the raw material of leaching. Very slow passage of liquors during the leaching process tends to check this disintegration.

The more the material is leached the more of these fines will be produced, until eventually the whole of the raw material will be reduced to this fine state, when all the soluble matter has been dissolved.

When the design of this type of leaching tank was first introduced, the raw material contained quantities of insoluble matter varying between 10 and 25 per cent. Nowadays this percentage varies between 50 and 70, and the tanks have not been redesigned to cope with this additional quantity of insoluble matter. The fine sand and slime thus deposited remains wetted with the strongest liquor, and even after washing is discharged with about 18/24 per cent nitrate. That which cannot get to the bottom remains in the charge and causes it to retain more nitrate liquor than otherwise, thus making the spent charge wetter and richer and increasing the inefficiency of the process.

As a result of the operation of this method of lixiviation, only about 45 to 55 per cent of the nitrate contents of the raw material are extracted as crystal, and an average oficina's working on 20 per cent material might be tabulated as follows, taking a unit of 1000 tons:

<i>General Statement of Work Done in Nitrate Plant</i>		
	Tons	Per cent
Nitrate contents, original.	200	
Nitrate extracted	100	50
Nitrate in Ripio (refuse)	40	20
Nitrate in Borra (fines)	20	10
Nitrate unaccounted for.	40	20
	200	100

In some of the still more modern works, owing to very large quantities of raw material handled (1500 to 2000 long tons per day), material as low as 18 per cent average is being worked successfully, and this success is due to the attention to and development of the mechanical side of the work, thus diminishing cost of power and labor, and by the size of the installation diminishing the proportion of fixed overhead charges.

No attempt will be made to enter into the question of costs in this article, except to say that with the general high cost of mining and of labor and fuel on the lixiviation plant the costs of operation are high. This coupled with the low efficiency of the whole scheme leaves a comparatively open field for new processes and methods of operation.

The foregoing will have given sufficiently clear an outline of the methods in use to-day for the refining of nitrate of soda, in which about 170 plants are engaged, ranging in output from 1500 tons to 7500 tons per month each, these including old type of machinery and the most modern of installations.

New Projects

As stated previously, within the last four years or so a huge impetus has been given to the interest taken in the improvement of the methods of refining, and a large number of projects have been suggested for this purpose.

A number of these schemes are in process of being tried on the large scale, while laboratory work is still being pushed forward in this direction.

The writer will endeavor to give an outline of the direction in which the work is tending, and although it will not be possible to refer to the inventors and workers by name it will readily be realized how near is the solution of the problem which is being tackled by numbers of workers who are transferring their knowledge of chemical, mining and metallurgical proc-

esses and adapting them to the needs of the nitrate industry.

The problem has been attacked from many points of view, and for clearness of description these may be divided into two classes:

- (1) Auxiliary processes.
- (2) Complete processes.

Auxiliary Processes

Auxiliary processes may be subdivided into various classes, but as a general statement it may be said that an auxiliary process is one which has been designed to remove some of the salient difficulties of the old process and to assist the latter to obtain better and cheaper production.

The subdivision of auxiliary processes may perhaps best be made as follows:

- (1) Those which have as their basis the screening of the raw material before treatment in the main plant.

- (2) Those which have as their basis the further treatment of the refuse material from the main plant.

Although the methods pursued by these two classes of auxiliary processes differ according to the nature of the prime material they deal with, their objects are the same inasmuch as they aim at procuring a liquor which can be strengthened to the necessary point for crystallization by being passed over raw material in the old type of plant.

SCREENING (AUXILIARY) PROCESSES

Such processes are based on the idea that one of the main causes of the inefficiency of the present method of lixiviation is the presence of "fines" in the crushed raw material, these fines being present in such material partly due to the crushing, partly to the breaking down of the conglomerate during blasting in the mining and falling in of soft overburden, and also to the natural friability of some of the material and the breaking down of it during handling.

By screening in rotary screens after crushing, and using about 3/16 mesh, varied proportions of fines are separated out of the varied crushed materials, but it is generally assumed that a cleaner and better leaching can be obtained in the old type of plant when it is fed with a screened product. No doubt this is true to some extent, but, as the leaching itself causes the production of fines in the tanks, the good results from the above will depend to a large extent on the nature of the raw material being treated in the original plant and will necessarily be limited by this.

From this point the methods adopted in the auxiliary processes for the treatment of the fines may be divided into three classes, depending as to whether

- (1) Grinding and vacuum filtration,
- (2) Pressure filtration, or
- (3) Classification and partial filtration

is adopted as the basis of the method of treatment.

In the first of these methods of treatment the fines (3.16 mesh) are ground in a ball mill with weak nitrate solution until a pulp is obtained of sufficient fineness (100 mesh) to permit it to be treated in a vacuum filter. The pulp is then heated up in order to cause solution of the nitrate contained in the solid and the hot pulp is filtered through a vacuum filter.

For this purpose the well-known and well-tried vacuum filters are used. The liquor which is withdrawn from the filter is sent to the main plant to be used as a feed liquor in the main operation, and the cakes are washed, first with a weak nitrate solution, and subsequently with a brine wash (the recovered washes being used in the cycle for the next treatment), the finished cakes being discharged practically barren of nitrate.

In the second of these methods the fines, without

grinding, are heated up with weak nitrate solution and filtered in pressure filters. The recovered liquor is sent as before to the main plant, the cakes being washed with weak nitrate solution, and finally with brine and discharged.

In the third the fines are treated with weak nitrate solution to complete the disintegration of the raw material, and the pulp obtained is classified in order to separate the slimes and fine sand (80 mesh). The remaining sands and stones are washed in a counter current system, being discharged with practically no nitrate content at all, while the slimes and fine sands are separated from the liquors obtained by vacuum or pressure filtration. The amount of solid filtered by this method is only about 20 per cent of the total insolubles and no grinding is necessary.

Whereas it is claimed in all three methods that complete lixiviation is procured and the refuse discharged with no nitrate contents at all, it is probable that costs of operation will be higher in the first and second methods than in the third method.

All these methods, however, leave this much to be desired. The proportion of fines which can be treated in the auxiliary plant is limited by the amount and ley of the cleaned coarse material sent to the main plant, because the auxiliary processes do not aim at the production of a directly crystallizable liquor, but only at one of such strength as can be sent to the main plant as a feed liquor.

If, as an example, 80 per cent of the nitrate in the raw material were contained in the fines the remaining 20 per cent in the coarse would not be sufficient to strengthen the liquors obtained from the auxiliary process unless such a process produced a correspondingly strong liquor. Of course, the removal of only a portion of the fines by screening, limits immediately the utility of the auxiliary processes by reducing the advantage gained in the main plant of treating cleaned coarse material.

The strength of liquor that can be obtained by the auxiliary treatment process is limited by many circumstances.

In the first case high temperature pulps (meaning high nitrate content of liquors) are not easy to handle, because of the tendency to rapid crystallization on the part of such liquors by cooling.

Secondly, the vacuum filter imposes a limit on the temperature of the liquor which can be passed through it and the pressure filter must be closely jacketed.

And lastly, if the pulp, after filtration and before washing, contains 30 per cent liquor content, which is quite likely to do by vacuum or pressure filter, this liquor will hold as much or more nitrate in the cake as the dry fines had in them before treatment. This means that the actual extraction of nitrate from the fines will be done by the first wash, which must in that case be an absolute displacement of the strong liquor, as mixing during the wash would reduce the strength.

Assuming fines of 14 per cent nitrate content to be treated for production of a liquor of 750 gm. nitrate per liter (say, 50 per cent nitrate by weight):

100 lb. fines equal say 14 lb. nitrate.

11 " salt,
75 " insolubles.

i.e., 86 lb. cake forming insolubles.

Liquor content of cake in or on filter before washing equals, say 30 per cent.

$$\begin{array}{rcl} \text{Then total weight of cake} & = & \frac{86}{70} \times 100 = 122.8 \text{ lb.} \\ \text{of which 86 lb. is insoluble} & & \frac{86.0}{36.8} \end{array}$$

This liquor being 50 per cent by weight of nitrate, there will remain in the cake 18.4 lb. nitrate. This excess over the 14 lb. nitrate originally present in the 100 lb. fines is taken from the extracting liquors. The wash must be a complete displacement wash or the 18.4 lb. nitrate will not be regained as liquor of 50 per cent strength.

Although there are limitations to the auxiliary processes of this kind themselves and to the use of them in connection with the main plant, they are being applied to the different plants at present in their limited capacity with very beneficial results.

The second class of auxiliary processes depends on the treatment of the refuse from the main plant by any of the three methods described above.

The whole of the refuse is ground in tube mills and either filtered or classified and partially filtered, with the result that the nitrate which would otherwise be discharged with the refuse on the dump tip is regained from it in the form of liquor which is used as a feed liquor in the main plant.

It will be obvious that the methods used in these auxiliary processes will be capable of application as a complete process, that is, one which will treat the whole of the raw material, if the liquors produced by them can be brought up to proper crystallizing strength by an efficient system of concentration and evaporation in the absence of being able to produce such liquors direct. It is claimed, however, that with the use of pressure filters such liquors can be easily obtained and the large-scale operations will prove later at what cost and what is the lowest ley of material which can be so treated.

An efficient process of evaporation would, however, make these auxiliary processes into complete ones and confer on them the ability to reduce the ley of the raw material to the minimum (thus reducing cost of mining considerably) by reducing the strength of the ultimate strength of solutions aimed at compatible with the costs of evaporation. In such an evaporation plant not only must the cost of evaporation be within commercial limits, but the design must be such as will efficiently cope with the greatest problem set before it in the handling of liquors which are below the saturation point for nitrate, viz., it must efficiently deal with the quantities of salt thrown out of solution during the evaporation. In working to the complete extraction of the nitrate contents of raw nitrate-bearing materials, not only will all the nitrate be dissolved, but also larger quantities of salt than heretofore, as well as the other soluble salts which may be present.

In concentrating the liquors obtained up to the necessary point to obtain crystallization of the nitrate contained, not only must the plant be capable of dealing with the salt thrown out of solution, and disposing of it free from nitrate, but it must be capable of producing so little mother liquor as to render easy the problem of disposing of the more soluble salts, such as calcium and magnesium chlorides and nitrates which would otherwise accumulate to the detriment of the process. Such a form of evaporator is now before the nitrate producers, and a plant capable of producing 2500 long tons per month is now being constructed in this country for delivery to Chile. The principles of this evaporation plant have been worked out in England on an experimental plant capable of producing 500 tons per month during a period extending over two and a half years, and in its present form it is confidently expected to reproduce the excellent results obtained in the trials and demonstrations carried out on the smaller scale.

In this type of plant, known as the Gibbs nitrate

evaporator, the above desiderata have been constantly borne in mind in addition to which continuity of operation has been sought for and arrived at.

The plant has been designed to act as a multiple effect evaporator, in the lower temperature effects of which part of the desalting is carried out, and in the final high temperature effect the temperature reached is so high as to practically complete the desalting. The desalted liquor is then crystallized by further evaporation in vacuum and the nitrate is regained as a continuous operation.

Special precautions have been incorporated in the design so as to prevent as much as possible incrustation of salts on the heating tubes, and also to provide for the settlement and removal of the deposited salt without interfering with the continuity of the operation.

The salt from each stage of the operation is washed and disposed of, and in the case of the salt separated at the high temperature it is collected and washed practically without loss of temperature, thereby preventing crystallization (and indirect loss) of nitrate with it. Wash liquors are returned to the evaporation system.

Complete Processes

With the introduction of an ultimate system of evaporation such as is outlined above, considerable assistance may be rendered to the development of what has been described as the auxiliary processes. In conjunction with such a system they become complete processes, and no doubt as the costs of the operations such as are used by these auxiliary methods are properly elucidated and compared the cheapest and most efficient of them will be gradually adopted as standard.

The inventors of the evaporation plant referred to at present place their faith in the lixiviation process which, through classification and partial filtration, carried out at a tepid condition of temperature only, arrives at a complete extraction of the soluble contents of the raw material producing a liquor of about 30 per cent nitrate content by weight. This liquor is produced by the lixiviation of the raw material with water as the starting point and no return of liquors from the evaporation section is made.

The lixiviation section has under these circumstances the best possible chance of yielding the best results.

The evaporation section is quite separate from the lixiviation section, and as it only produces sufficient mother liquor to enable the crystal nitrate to be removed from the plant and dried in hydroextractors, this mother liquor is able to retain the more soluble salts together with the remaining sodium chloride, due to incomplete desalting. This mother liquor can be discharged from the cycle for purification periodically and sent back to the evaporation plant practically only carrying nitrate of soda. With such a complete process the cost of operation will be made up of cost of mining, cost of lixiviation, cost of evaporation, and these three factors can be adjusted to each type of material, depending on its original nitrate content and the strength of solution it is best to work for.

It is on these lines that the development of the refining of Chile saltpeter is taking place, and the ground is well prepared for such development.

Capital has interested itself in the newer ideas and objections to the introduction of completely new methods have died away or are slowly dying.

Rivalry between the workers on the development schemes on a healthy scale is assisting rather than hindering the progress, and from all points of view it must be agreed that a very bright future is assured to the Chilean industry from the results which will follow:

1. Increase in estimated life of properties.
2. Decrease in working costs.
3. Decrease in costs of newer installations.
4. Reduction of labor difficulties.
5. Increased control over methods of refining and mining.
6. Attraction of new capital and new blood to the industry due to its new activity and life.

The Analysis of Light Oils

Contribution from the Haysmeyer Chemical Laboratory,
Columbia University No. 293.

By Gustav Egloff

The rapid, safe and accurate analysis of light oils resulting from the thermal decomposition of coal, shale or petroleum oil for their benzene, toluene and xylene content is of considerable industrial importance. In this communication a method is described which embodies the essentials of safety from fire, reasonable rapidity and a relatively high degree of accuracy. The still used consists essentially of an eight-foot column of iron pipe, of foot lengths of iron pipe, with a reflux tube running below the distilling liquid in a copper flask of four liters capacity. The still was tested experimentally with varying percentage composition mixtures of benzene, toluene and xylenes. The concentration of benzene studied ranged between 2.0 to 80 per cent; the toluene between 3.0 and 90 per cent, and 6 to 58 per cent for the xylene concentration.

In addition to the determination of the accuracy of the still, an outline of the washing of a light oil free of olefins, neutralizing, steam distillation, drying and percentage composition of paraffins, benzene, toluene and xylenes (or solvent naphtha) present will be given.

DESCRIPTION OF STILL

a. The column, eight feet in length, is made up of six sections of three-quarter inch pipe, one foot each in length, another eighteen inches in length, and one section of one and one-half inch pipe, six inches long. Each section is connected by means of a sleeve, and the last section with a three-quarter, one and one-half inch reducer. Between adjacent sections there is a 30-mesh iron gauze used as a diaphragm to support an eight-inch column of two-inch glass rods of one-eighth-inch diameter.

b. The reflux part of the column is made from one-quarter-inch pipe, and is six and one-half feet in length. It taps into the column six inches from the top, extends downward on the outside, and enters the column a

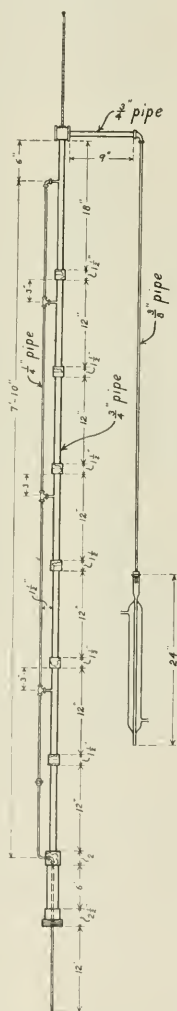


FIG. 1—STILL CONSTRUCTION

foot from the bottom at the top of the one and one-half inch diameter section. It extends to within one inch of the bottom of the copper flask when the whole apparatus is connected. Three one-quarter inch elbows and tees, one one-quarter inch reducer union are used to make the fittings. Three one-quarter inch nipples tap into the three-quarter inch pipe, as shown in the drawing.

c. Attached to the top of the column is a tee which allows a thermometer to be inserted through one opening, and a three-quarter inch pipe in a horizontal direction, nine inches in length. At the end of this horizontal section is a reducing elbow of three-quarter one-half inch. A half inch pipe extends downward from this reducer, to a twenty-four inch condenser.

d. The connection between the column and the copper flask is made by means of a one and one-half inch Dart union, one section of which is connected to the bottom of the column, and the other to the neck of the flask.

e. The flask is made of copper with a capacity of 4000 c. c. It has a flat bottom of six inches diameter. To the neck, a one-one-half inch Dart union is brazed. The flask may be varied in size dependent upon the quantity of oil desired.

f. In order that the distillation may proceed evenly, it is best to surround the burners with a three-way asbestos screen to prevent drafts. It has also been found advisable to set the column in a box with a hinged door, which may be opened and shut at will. This door is closed at higher temperature distillations. This precaution is not necessary if the distillation is conducted in a room, which is free from drafts.

g. The manipulation of distillation is quite simple, although care must be exercised when first applying heat to the flask. If too much heat is applied the system floods. The reflux is not sufficient to carry off the column of liquid lifted by the supporting vapors. One can note the process of distillation by the temperature of the various sections of iron pipe, by simply touching. The rate of distillation is exceedingly important, for without this control a good separation is impossible. The work of Brown² has clearly emphasized the fact that the rate of distillation influences greatly the separation of mixtures. The data in Table 1 show experimentally the wide differences resulting, when thirty, sixty or one-hundred and twenty drops per minute are used, in distilling a benzene and toluene mixture.

TABLE 1
Mixture of Benzene and Toluene

Temperature Range	Number of Drops of Distillate per Minute		
	30	60	120
Percentage Weight of Distillate			
80.2-83.2	0.8	0.6	0.6
83.2-86.2	29.6	21.8	10.8
86.2-89.2	9.8	14.3	20.2
89.2-92.3	7.6	7.8	12.6
92.3-95.4	3.8	5.0	7.0
95.4-98.5	3.0	4.7	5.4
98.5-101.6	2.8	4.0	5.0
101.6-104.6	2.0	3.6	5.0
104.6-107.6	4.3	5.2	5.6
107.6-110.6	6.2	7.3	9.2
110.6-116.6	11.6	9.8	11.1
Pure toluene by difference	19.5	15.9	7.6*
	100.0	100.0	100.0

*Temperature barely reached 110.6, residue not quite pure toluene.

In the present work two drops per second were found to be satisfactory. The two drops per second were checked by means of a metronome and stop watch. The end of the condenser was cut off square, so as to obviate constrictions, which would give a different size drop, hence affecting the rate of distillation.

Two thousand c. c. of mixtures of benzene, toluene and xylenes were distilled in each experiment. The

¹Shown in Fig. 1.

²Trans. Chem. Soc. 37, 49, 1880.
³Young's "Fractional Distillation."

average time of distillation was four hours and thirty minutes, or approximately seven and one-half c. c. per minute. The concentrations used for benzene ranged between 2.0 and 80 per cent; toluene, 3.0 and 90 per cent, and for the xylenes, 6 to 53 per cent.

The cuts were made at 95 deg. C. for benzene; and 95 deg. to 125 deg. C. for toluene.

The volumes of benzene, toluene and xylene were measured by means of calibrated measuring cylinders of 500 c. c. capacity. The smaller volumes were measured by means of a standardized burette of 100 c. c. capacity.

h. The purity of the benzene, toluene and xylenes used was of a relatively high order. They were water-white in color, and gave no color upon treatment with c. p. 1.84 specific gravity sulphuric acid. The benzene gave no test for thiophene by means of the indophene reaction. The distillation of the benzene, toluene and xylenes was made in a standard 200 c. c. Engler flask (Table II.). The specific gravity was taken by means of a Westphal balance at 15.5 deg. C.

TABLE II
Engler Distillation of Benzene, Toluene and Xylenes

Per cent by vol.	Sp.Gr.0.881	Sp.Gr.0.871	Sp.Gr.0.869
First drop	79.5° C	109.1° C	137.1° C
2.5 per cent.....	80.1° C	109.8° C	138.2° C
5.0 per cent.....	80.3° C	110.0° C	138.3° C
95.0 per cent.....	80.7° C	110.4° C	139.4° C
97.5 per cent.....	80.9° C	110.5° C	139.6° C
Dry point	81.3° C	110.7° C	140.0° C
Distillation range.	1.8° C	1.6° C	2.9° C

i. The advantages of the proposed still may be summed up as follows:

1. It has a relatively high degree of accuracy in determining the percentage composition of aromatic hydrocarbons present in a light oil.

2. It allows of large quantities of liquid to be distilled.

3. The apparatus is not liable to break, is inexpensive and makes the distillation of inflammable liquids relatively safe from fire hazards.

4. The distillation losses are small, due to one fractionation only being necessary and very small amount of residual liquid remaining in the fractionation column.

5. It is simple to operate and requires little attention after being regulated. One individual can operate four stills at one time.

6. It contains in essential the advantages outlined by Young.⁴

"Fractional Distillation," 1903, p. 176-177.

DISCUSSION OF DISTILLATION DATA OF KNOWN MIXTURES

TABLE III
Distillation Analysis of Varying Per Cent of Benzene, Toluene and Xylene

Per Cent Benzene	Per Cent Toluene	Per Cent Xylene	Per Cent Benzene Recovered	Per Cent Toluene Recovered	Per Cent Xylene Recovered	Per Cent Benzene Residue	Per Cent Toluene Residue	Per Cent Xylene Residue	Per Cent Benzene Losses	Per Cent Toluene Losses	Per Cent Xylene Losses
8.0	80.3	13.3	13.0	6.7	6.3	0.4					
78.3	78.4	11.7	10.0	9.7	0.2						
76.7	76.7	3.3	3.4	20.0	19.3	0.6					
75.0	75.8	12.7	12.7	12.3	9.7	1.8					
73.3	74.0	13.3	13.6	13.4	12.3	0.1					
70.0	71.0	10.0	10.8	20.0	18.2	0.0					
66.7	67.1	13.3	14.0	20.0	18.8	0.1					
63.3	64.0	16.7	17.3	20.0	18.7	0.0					
60.0	60.3	13.3	14.0	26.7	25.6	0.1					
53.3	53.2	13.3	14.1	33.4	31.8	0.9					
46.7	47.7	33.3	34.3	20.0	18.0	0.0					
46.7	46.2	13.3	14.2	40.0	39.6	0.0					
43.3	43.3	36.7	37.3	20.0	19.3	0.1					
40.0	41.2	40.0	40.2	20.0	18.5	0.1					
40.0	40.4	13.3	13.9	46.7	45.3	0.4					
33.3	33.2	46.7	43.3	20.0	17.5	1.0					
30.0	29.8	50.0	49.5	20.0	20.7	0.0					
26.7	26.0	53.3	54.6	20.0	18.9	0.5					
26.7	26.2	15.3	15.0	58.0	58.3	0.4					
23.3	23.0	56.7	59.0	20.0	17.8	0.2					
20.0	20.0	60.0	62.0	20.0	17.6	0.4					
13.3	12.5	66.7	68.1	20.0	18.0	1.4					
10.0	9.2	70.0	70.0	20.0	18.9	1.6					
6.0	5.3	88.0	89.0	6.0	5.2	0.5					
2.3	0.8	89.3	91.0	8.4	8.2	0.0					

Table III tabulates the analytical results of various concentrations of benzene, toluene and xylene. The

data speak for themselves, showing the relatively high order of analytical accuracy of the type of still used in the above set of experiments. It must be recognized that the benzene recovered in the cut to 95 deg. C. is not pure benzene, but contains a small per cent of toluene, as likewise the toluene cut of 95 deg. to 125 deg. C. contains a small per cent of benzene and xylene. But the percentage of the constituent contaminating the fraction from the viewpoint of absolutely pure substance balance each other, so that for analytical purposes of industrial significance, the cuts to 95 deg. C. (benzene), 95 deg. to 125 deg. C. (toluene), may well be taken as the actual amounts of benzene and toluene present in the starting mixture.

In actual distillation the benzene comes over mainly, close to its boiling point of 80.2 deg. C. The thermometer climbs rapidly, with little liquid coming over to the boiling point of toluene of 110.6 deg. C. Likewise for the amount coming over between the boiling point of toluene and the xylenes of 137 deg. to 140 deg. C. To separate the mixture into pure benzene, toluene and xylene a number of redistillations would be necessary for their separation.

TABLE IV
PRIMARY OIL

	Percentage by Volume	Specific Gravity
Benzene	70	0.881
Toluene	15	0.871
Xylenes	15	0.869

Engler Distillation of Mixture of Benzene, Toluene and Xylenes	Temperature, Deg. C.	Per Cent by Volume
First drop	82.5	0.0
	85.0	9.0
	90.0	47.7
	100.0	80.2
	110.0	82.4
	120.0	88.0
	130.0	93.6
	135.0	96.2
	137.5	Dry point

Distillation Results	Per Cent by Vol.	Sp. Gr.	Hempel Column, Per Cent by Vol.	Sp. Gr.
Temperature (Benzene Cut) 0-95° C.	70.3	0.881	69.8	0.881
(Toluene Cut) 95-125° C.	15.1	0.870	14.2	0.869
Residue	12.5	0.869	14.2	0.870
Loss	2.1	....	1.8	....

Engler Distillation of Cuts

	0-95 Deg. (Benzene Cut)	95-125 Deg. (Toluene Cut)
Per Cent by Volume	8' Column, Deg. C.	Hempel Column, Deg. C.
First drop	78.8	77.9
2.5	79.4	79.2
5.0	79.9	79.7
95.0	82.9	82.1
97.5	85.0	86.9
Dry point	86.9	89.9
Distillation range	8.1	12.0
	Residue	8' Column, Deg. C.
First drop	133.9	131.9
2.5	134.9	132.9
95.0	135.0	133.4
97.5	139.5	138.9
Dry point	139.9	140.1
Distillation range	140.0	140.9
		9.0

TABLE V

SECONDARY OIL

	Percentage by Vol.	Specific Gravity
Benzene	30	0.881
Toluene	25	0.871
Xylenes	45	0.869

Engler Distillation of Mixture of Benzene, Toluene and Xylenes	Temperature, Deg. C.	Percentage by Volume
First drop	94	0.0
To	95	0.2
	100	5.5
	110	34.7
	120	56.1
	130	77.3
	135	88.2
	137.7	Dry point

Distillation Results	Per Cent by Vol.	Sp. Gr.	Hempel Column, Per Cent by Vol.	Sp. Gr.
Temp. (Benzene Cut) 0-95° C.	30.2	0.881	29.6	0.881
(Toluene Cut) 95-125° C.	25.5	0.870	24.8	0.870
Residue	44.0	0.869	44.5	0.869
Loss	0.3	....	1.1	....

Engler Distillation of Cuts

Per Cent by Volume	6-95 Deg. (Benzene Cut)		95-125 Deg. (Toluene Cut)	
	Column, Deg. C.	Hempel Column, Temp. Deg. C.	Column, Deg. C.	Hempel Column, Temp. Deg. C.
1st drop	79.9	78.8	107.3	101.2
2.5	80.9	80.3	108.7	104.9
5.0	81.2	80.9	109.0	105.5
95.0	90.4	92.0	122.4	124.3
97.5	99.7	101.0	128.9	129.0
Dry point	100.9	102.0	130.9	132.8
Distillation range	21.0	23.2	23.6	31.6

Residue

Per Cent by Vol.	8' Column, Temp. Deg. C.	Hempel Column, Temp. Deg. C.
1st drop	133.0	130.8
2.5	133.5	132.3
5.0	134.0	132.9
95.0	138.5	138.3
97.5	138.9	138.5
Dry point	139.1	138.9
Distillation range	6.1	8.1

TABLE VI—PINTSCH HYDROCARBON OIL

	Percentage by Volume	Specific Gravity
Benzene	55	0.881
Toluene	8	0.871
Xylenes	37	0.869

Engler Distillation of Mixture of Benzene, Toluene and Xylenes

	Temperature, Deg. C.	Per Cent by Volume
First drop	84.9	0.0
To	90.0	7.4
	100.0	45.3
	110.0	63.8
	120.0	70.0
	130.0	77.8
	135.0	83.2
	139.2	Dry point

Distillation Results

Temp.	8' Column		Hempel Column	
	Per Cent by Vol.	Sp. Gr.	Per Cent by Vol.	Sp. Gr.
(Benzene Cut) 0.95°C.	54.9	0.881	54.4	0.880
(Toluene Cut) 95-125°C.	8.3	0.870	7.0	0.871
Residue	36.5	0.869	38.6	0.869
Loss	0.2		0.0	

Engler Distillation of Cuts

Per Cent by Volume	6-95 Deg. (Benzene Cut)		95-125 Deg. (Toluene Cut)	
	Column, Deg. C.	Hempel Column, Temp. Deg. C.	Column, Deg. C.	Hempel Column, Temp. Deg. C.
First drop	78.6	77.4	103.6	101.1
2.5	79.0	79.3	105.0	103.4
5.0	79.2	79.8	106.6	105.0
95.0	82.6	83.8	131.2	130.1
97.5	85.0	85.8	132.2	133.2
Dry point	90.0	93.0	135.0	134.5
Distillation range	11.4	15.6	31.4	33.4

Residue

Per Cent by Volume	8' Column, Temp. Deg. C.	Hempel Column, Temp. Deg. C.
First drop	131.0	130.1
2.5	132.0	131.4
5.0	132.5	131.9
95.0	137.0	137.9
97.5	137.6	138.0
Dry point	138.0	139.4
Distillation range	7.0	9.3

The analytical data in Tables IV, V, and VI represent mixtures of commercial concentrations from by-product coke-oven plants and the Pintsch gas process and are known as primary, secondary, and hydrocarbon oil. To compare the present single distillation method in an 8-ft. column, a standard Hempel column (shown in Fig. 2) was used with a flask of 500 c.c. capacity. The great advantages of the Hempel apparatus are efficiency, simplicity and ease of manipulation. But,

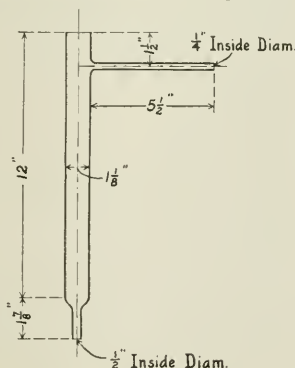


FIG. 2—HEMPEL COLUMN

three distillations are necessary when a Hempel column is used, as has already been shown in another communication.⁶ To indicate the temperature range of the distillation of the fractions, a standard Engler flask of 200 c.c. capacity was used. The distillation was made in each case for each fraction using 100 c.c. samples of the benzene cut, to 95 deg. C., toluene cut 95 deg. to 125 deg. C., and the residue. The Engler distillation of the cuts gives important information as to the efficiency of the fractionation. The temperature range over which the cuts distil is given comparatively for the 8-ft. and Hempel column, in the following table:

	Temperature Range, Benzene Cut		Temperature Range, Toluene Cut		Temperature Range, Residue	
	8' Col., Deg. C.	Hempel, Deg. C.	8' Col., Deg. C.	Hempel, Deg. C.	8' Col., Deg. C.	Hempel, Deg. C.
Primary oil	8.1	12.0	20.2	22.0	6.1	9.0
Secondary oil	21.0	23.2	33.6	31.6	6.1	9.1
Hydrocarbon oil	11.4	15.6	31.4	33.4	7.0	9.3
Light oil from cracked petroleum	56.5	60.5	31.0	31.5	110.0	115.5

The temperature range at which the benzene, toluene and xylene cuts distil indicates quite clearly that a considerably better fractionation of the starting oil has been accomplished in one distillation with the 8-ft. column in comparison to three fractionations with the Hempel column.

TABLE VII
Light Oil from Cracked Petroleum
Specific Gravity, 0.801 at 15.5 Deg. C.
Engler Distillation of Original Oil

	Temperature, Deg. C.	Percentage by Volume
First drop	42.5	0.0
To	50.0	0.8
	60.0	3.0
	70.0	7.5
	80.0	16.0
	90.0	26.0
	100.0	33.0
	110.0	50.0
	120.0	59.2
	130.0	66.2
	140.0	72.5
	150.0	76.1
	160.0	80.0
	170.0	82.1
	180.0	84.8
	190.0	86.4
	200.0	88.5
	210.0	90.0
	220.0	91.2
	230.0	92.5
	235.0	Dry Point

Distillation Results

Temperature	8' Column		Hempel Column	
	Per Cent by Vol.	Sp. Gr.	Per Cent by Vol.	Sp. Gr.
(Benzene Cut) 0.95°C.	46.5	0.753	47.0	0.754
(Toluene Cut) 95-125°C.	23.2	0.821	23.6	0.821
Residue	28.5	0.858	27.5	0.859
Loss	1.8		1.9	

	Per Cent Benzene	Per Cent Toluene	Per Cent Xylenes
8' column	9.8	16.0	25.2
Hempel column	9.9	15.3	24.8

Engler Distillation of Cuts

Per Cent by Volume	6-95 Deg. (Benzene Cut)		95-125 Deg. (Toluene Cut)	
	Column, Deg. C.	Hempel Column, Temp. Deg. C.	Column, Deg. C.	Hempel Column, Temp. Deg. C.
First drop	41.5	42.5	105.0	104.5
2.5	48.0	51.5	106.0	106.8
5.0	52.0	54.3	106.5	107.0
95.0	86.0	93.0	124.8	127.0
97.5	90.0	96.0	130.5	132.0
Dry point	98.0	103.0	136.0	136.0
Distillation range	56.5	60.5	31.0	31.5

Residue

Per Cent by Volume	8' Column, Temp. Deg. C.	Hempel Column, Temp. Deg. C.
First drop	140.0	140.5
2.5	143.0	145.0
5.0	145.2	147.0
95.0	234.5	233.0
97.5	240.0	243.0
Dry point	250.0	256.0
Distillation range	110.0	115.5

The data in Table VII express the analytical results of the percentage composition of the benzene, toluene

⁶Rittman, Twomey and Egloff, This Journal, V. 13, p. 682, 1915.

and xylene in a light oil resulting from the thermal decomposition of a petroleum oil. The percentages of the aromatics present were calculated by means which are given in the following section. In analyzing the exceedingly complex mixture of a cracked petroleum light oil, where the olefin, paraffin, naphthene and aromatic hydrocarbons present, have similar boiling points, it is practically impossible to separate them by fractionation; hence the analytical results of the aromatic hydrocarbons present are very likely not accurate to closer than 5 per cent.

Method of Analysis for Light Oil SPECIFIC GRAVITY

The specific gravity of the oil and of the distillates is determined by means of a Westphal balance at 15.5 deg. C.

OLEFINS

A sample of 2000 c.c. of the original oil is measured accurately in a graduated cylinder and transferred to a bell jar of 3000 c.c. to 4000 c.c. capacity, with a glass stop cock cemented in the lower part. Setting within the bell jar is a 1½-in. diameter lead coil, for water circulation. A lead paddle wheel is utilized for stirring which can be run by a system of gearing from a small motor. A lead plate covers the bell jar through which suitable holes allow of the stirring device, cooling coil, and place for a 500 c.c. separatory funnel.

While the cooling water circulates through the lead coil and stirring goes on, 200 c.c. of 95 per cent C. P. sulphuric acid is run into the light oil at the rate of one drop per second or approximately 3¾ c.c. per minute. The deolefinizing of the 2000 c.c. sample requires one hour and twenty minutes or so.

After the addition of the 200 c.c. of 95 per cent sulphuric acid the system was allowed to stand for one-half hour, so as to give time for the two liquid layer systems to reach equilibrium. The acid layer which contains sulphonic acids of the olefin series hydrocarbons, and other complexes, is separated. After the removal of the acid sludge, the acid dissolved in the light oil is neutralized with a 6 per cent solution of caustic soda. The caustic soda solution and oil are stirred for fifteen minutes and allowed to stand for thirty minutes. The caustic soda sludge is then drawn off.

STEAM DISTILLATION

All the oil residue so obtained, freed from olefins as above, is now placed in a copper container of four liters capacity and distilled with live steam until the temperature reaches 180 deg. C., at which point practically all the light oil has distilled off. The condensed water is separated by means of a separatory funnel and the light oil thoroughly dried with fused calcium chloride. After drying, the oil is filtered free of calcium chloride. The dried oil is distilled by the method already given.

The distillate collected up to 95 deg. C., is the benzene fraction, that collected from 95 deg. C. to 125 deg. C. is the toluene fraction, and that collected from 125 deg. C. to 165 deg. C. is the solvent naphtha fraction. The volume of each of these fractions is carefully determined and the specific gravity of each fraction is taken at 15.5 deg. C. by means of a Westphal balance.

If the specific gravity of the benzene fraction is not below 0.880, that of the toluene fraction not below 0.871, and that of the solvent naphtha fraction not below 0.870, these fractions contain no paraffins, and their respective volumes represent the amounts of pure benzene, pure toluene and pure solvent naphtha in the 2000 c.c. of oil originally taken. If the specific gravities of the fractions are below the figures given, then paraffins are present and corresponding deduction must therefore be made.

PARAFFINS

A method of calculating the percentage of paraffins present in the benzene and toluene cuts is based upon the wide difference between the specific gravity of the paraffins and aromatics. The average specific gravity of the paraffin hydrocarbons to 95 deg. C. is 0.720 while the value for benzene is 0.881. For toluene the value is equal to 0.871 while the paraffins in this cut of 95 deg. C. to 125 deg. C. are equal to 0.730. The following numerical example will make the process of calculation clear.

Cut to 95 Deg. C.	
Specific gravity, paraffin hydrocarbons.....	0.720
Specific gravity, benzene.....	0.881
Specific gravity of cut to 95 deg. C.....	0.841
Subtract 0.720 deg. from 0.841 deg.....	12
Subtract 0.720 deg. from 0.881 deg.....	16

12
Assume that 75 c.c. collects in cut to 95 deg. C. —
16

× 75 c.c. = 56.2 c.c.'s benzene in cut to 95 deg. C.

Since 2000 c.c. was used, the percentage of benzene in the sample is 2.8.

The quantity of paraffins contained in the several distillates is experimentally determined in the following way (which gives fair values of the percentage present).

Ten cubic centimeters (10 c.c.) of distillate are mixed with 25 c.c. of a mixture of two parts by volume of sulphuric acid (specific gravity 1.84) and one part by volume of 20 per cent oleum (fuming sulphuric acid). The mixture is thoroughly agitated in a 50-c.c. graduated cylinder with glass stopper and then allowed to settle.

Any paraffins present remain undissolved and their volume so determined divided by ten and multiplied by the total number of cubic centimeters in the particular distillate being examined gives the total volume of paraffins contained in said distillate. This quantity deducted from the total volume of distillate gives the net volume of distillate.

The percentage of benzene and toluene corrected for the paraffins if present in the light oil, are calculated as follows:

$$\frac{\text{Percentage of hydrocarbon}}{\frac{\text{Corrected volume of fraction}}{2000}} \times 100.$$

SPECIFICATIONS FOR BENZENE AND TOLUENE

In the use of benzene and toluene for the formation of phenol or picric acid and trinitrotoluene fairly rigid specifications are demanded as to their specific gravity, boiling points, color and sulphuric acid test. The following outline covers specifications which allow of their use for the above-named compounds, in the usual industrial operation.

Appearance:

(a) The toluene and benzene shall be water white in color and clear.

Specific Gravity:

(b) The specific gravity of toluene shall be between 0.869 and 0.872 at 15.5-15.5 deg. C.

The specific gravity of benzene shall be between 0.879 and 0.884 at 15.5-15.5 deg. C.

Boiling Point:

(c) The toluene shall boil within plus or minus 1 deg. C. of its boiling point of 110.0 deg. C. Of a 100 c.c. sample 90 per cent shall distil within 0.5 deg. C.; 95 per cent within 1.0 deg. C. The first drop shall not distil below 109.0 deg. C. and dry at 111.0 deg. C.

The benzene shall boil within plus or minus 1 deg. C. of its boiling point of 80.2 deg. C.; 95 per cent of its volume shall distil within 1.1 deg. C.

Sulphuric Acid Test:

(a) The toluene and benzene shall not impart more than a very faint straw color to sulphuric acid of 95 per cent concentration.

Method of Testing:

Specific Gravity—

(b) Determine by means of a Westphal balance, correct the result so as to compare the toluene at 15.5 deg. C. with water; also at 15.5 deg. C.

Boiling Point:

(c) Employ a 200-c.c. distillation flask with outlet tube $1\frac{3}{4}$ above the bulb. Connect to a Liebig condenser about 24 in. long over-all with a straight condenser tube unobstructed at the end. Place 100 c.c. of the sample of the toluene or benzene in the flask and adjust a thermometer graduated in tenths of a degree C. so that the top of the bulb is on a level with the side tube. Apply heat to a small area over the bottom of the flask and conduct the distillation in such a manner that the distillate passes over as quickly as possible in distinct drops. Collect distillate in a 100 c.c. graduated measure, read the temperatures at which (a) first drop of distillate falls from the end of condenser; (b) 2.5 c.c.; (c) 5 c.c.; (d) 9.5 c.c.; (e) 97.5 c.c. have collected. Finally record the temperature when the flask just becomes dry. Correct the readings for exposed mercury column and for barometric pressure. Allow 0.043 deg. C. per m.m. difference from normal atmosphere.

Sulphuric Acid Test:

(d) Shake for five minutes 50 c.c. toluene or benzene and 5 c.c. of 95 per cent sulphuric acid in a cylinder fitted with ground glass stopper. After settling, the color of the acid layer is observed. It should not be darker than pale, straw yellow.

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The Determination of Zinc

By J. H. Hastings

Both the American Chemical Society¹ and the Australian Institute of Mining Engineers² have had committees working on the subject of a standard method for the determination of zinc in ores and each have recommended for adoption a different method than the one in common use by chemists and assayers in the West and to a somewhat more limited extent in the East. The former recommended Waring's method, slightly modified, and the latter the titration in an alkaline solution.

We are indebted to A. H. Low³ for the general scheme of the titration of zinc in an acid solution as commonly used. I shall outline his method as modified for works' use, and for simplicity take for example an ore that is decomposed by nitric acid and potassium chlorate.

Weigh 0.5 gram into No. 2 (250 cc. capacity) beaker; add 0.5 gram potassium chlorate, cover with watch glass and add 10 cc. HNO₃. Wait until first violent action ceases, a minute or two, place on hot plate or sand bath, and run to dryness slowly; have the beaker just hot enough so that the mass will froth up about one inch. When dry, tip up cover and catch drop against the side of beaker. Remove from heat. It is no advantage to leave the beaker on plate after the contents are dry, but rather is to be avoided, and take care not to allow the contents to fuse. This last precaution is taken to facilitate the later solution of the zinc. Cool, add 7 grams ammonium chloride, 20 cc. ammonia, 5 cc. bromine water (the last for ores containing little or no manganese), and fill the beaker one-half full with hot water. Boil from four to six minutes at a moderate

heat. For ores containing much manganese, add 15 cc. bromine water at first and 10 cc. more after contents have boiled one or two minutes, still boiling the total time of from four to six minutes. Remove, filter through a No. 3 Munktell or similar filter paper into a No. 3 (350 cc. capacity) beaker, washing off cover and down sides of beaker with hot water. In filtering pour on the side of filter paper to avoid splattering and have the stem of the funnel against the filtrate beaker, so that the liquid will run down the side and not just drop into the liquid already in the beaker and spatter out, causing loss of zinc solution. Wash out beaker and wash precipitate ten to twelve times with the wash solution made by dissolving 100 grams ammonium chloride in hot water, adding 50 cc. ammonia and making up to one liter.

Add a couple drops of saturated solution of methyl orange solution, neutralize with hydrochloric acid and add 5 cc. excess. The volume should now be 200 cc., and with some practice the washings can be gauged so that this will be the case.

Heat to boiling, add 50 cc. saturated H₂S water, and titrate slowly, stirring briskly, using 5 per cent solution uranium nitrate for indicator. It is best to work with a reserve portion, say 20 cc., and add portions of it until the final end point is reached.

Oxidized ores may be treated with 10 cc. hydrochloric acid, evaporated to a few cc., but not far enough for any part of the bottom of the beaker to be dry, as this condition may result in loss of zinc through volatilization. The acid should not boil.

To standardize, weigh out the same amount of zinc as the ore contains, so that the titration will be within 10 cc. of the number cc. the titration of the ore will require. The metallic zinc used should be specified for standardizing and marked with the analysis of the manufacturer.

GENERAL DISCUSSION

Decomposition: The safest manner to decompose sulphide zinc ore is with the 5 gram potassium chlorate and 10 cc. nitric acid. This procedure results in partial precipitation of the manganese and makes a good body from which the zinc can subsequently be extracted without any trouble. The precipitation of the iron and manganese and partial extraction of the zinc in the manner indicated is quite efficient, but the zinc remaining in the iron precipitate must be extracted. This zinc is more or less insoluble in a solution of ammonium chloride, weaker than 10 per cent.

As to redissolving this precipitate and reprecipitating, much less of the zinc will be carried down the second time, and possibly with a third precipitation the zinc could be entirely extracted, at least with the limitations of the analysis. I have heard of six such precipitations being made. The chance for loss is apparent. One chemist told me that he had made three such precipitations in a determination on an ore which he thought contained manganese and he was laboring under the delusion that this procedure would separate the manganese from the zinc, when, as a matter of fact, it hinders that separation to redissolve this precipitate, as some manganese has already been precipitated by the chlorate and nitric acid. At any rate it was quite evident that the ore in question contained no manganese, as this metal, if in appreciable quantity (enough to effect the zinc determination), is shown by the brownish color of the mass on the first evaporation and the residue on this ore was pure white.

Another method of extracting the zinc from the iron precipitate is to add 50 c.c. alkaline, 10 per cent ammonium chloride solution and boil. It is a hard matter to thoroughly extract the zinc in this manner, as some of the zinc is apt to reprecipitate as the boiling continues and there is a state of equilibrium reached when

¹J. Am. Chemical Soc. 1907-29-265.

²Proceedings—1913-10.

³Methods of ore analysis, 1913. Chp. XXX, p. 284.

while some zinc is dissolving some zinc is reprecipitating, and besides if all the zinc is dissolved the next procedure in this modification is washing four to six times with hot water, in which case some of the zinc is likely to reprecipitate on the filter upon dilution with water. This is an explanation, I believe, of why some results are low on ore running from 40 to 50 per cent zinc and 8 to 10 per cent iron.

The process of washing is very important, and it is unfortunate that analysts are, as a rule, untrained in this phase of chemical manipulation. There are certain ores on which it is difficult to extract the zinc from the iron precipitate. For instance, an ore running 16 per cent zinc and 30 per cent iron, or one containing 43 per cent zinc and 15 per cent iron, I have found difficult, and to require twelve washings instead of ten.

To wash the precipitation, have the extraction solution nearly boiling. On the first washing, start at the rim of the filter paper and wash around a couple of times, descending to the point of the filter. On subsequent washings wash down the point of the filter, stirring the iron precipitate well, say, the lower inch of the filter; then, still washing, circle around the filter paper with wash stream, gradually working up to the rim of the paper, and then around down to the vortex again, giving the iron precipitate a final churn with the stream. This leaves about an inch of liquid, measured up the side of the paper, in the filter. Keep blowing just hard enough so that the stream will not break the filter paper, but blow as hard as the filter paper will stand. The volume of the filtrate will be about 200 to 225 c.c. This makes about 12 to 13 c.c. for each washing. Several small washings are more effective than a few large ones.⁴

Neutralizing should be done carefully and exactly 5 c.c. hydrochloric acid added in excess as the uranium ferrocyanide is slightly soluble in hydrochloric acid, depending on the strength.⁵

The beaker is covered, set on a warm place until ready to titrate, then brought to a boil and the 50 c.c. hydrogen sulphide water added. It is not necessary to boil out the bromine, but it does no harm to do so.

The titration is perhaps the most difficult part of the whole determination to master. In the first place, provided the solution has been standardized correctly, it is not likely for one to get low results through faulty titration. But, on the other hand, it is a simple matter to be too high. We will assume that the standard solution is correct; then for a novice to hope to be correct in his results he must bear in mind several things. One of the first is to have a saturated hydrogen sulphide solution in an amber-colored stoppered bottle.

Have this solution strong enough so that you cannot stand more than one strong sniff of it. Add 50 c.c. to the zinc solution, stir well for several seconds. Pour off, say, 20 c.c. Run in the standard solution slowly, stirring vigorously, until after testing from time to time the end point is reached. The zinc solution generally turns milky at this stage, but it takes some experience to be able to note this change. Then add half the 20 c.c. and again titrate to an end point, repeat with half the remaining 10 c.c., then run very carefully until the end point is again reached and put in final 5 c.c., and finish the titration. When the last 5 c.c. are emptied into the main beaker the solution is poured back into the first beaker. Repeat to rinse the reserve beaker. The proper way to stir the solution is to stir once around about half way down between the center and sides of the beaker; then reverse and

stir back to the starting place. Repeat this operation about three times, then stir from one side of the beaker to the other through the center, repeating this procedure three times. This is the general idea of thoroughly churning up the liquid with little danger of splashing any out of the beaker. I might say that the stirring cannot be done effectively with a glass rod, but it is better to use a hard rubber rod with a soft rubber tip, so as to avoid breaking the beaker.

The end point is the first faint change to a reddish color. A "fake end" point sometimes shows up, especially if the titration is carried on rapidly. This sometimes shows up as early as 10 c.c. before the true end point, but can be detected by the fact that it does not get deeper in color if more ferrocyanide solution is added.

A turning green of the solution can be accounted for either by the decomposition of the potassium ferrocyanide through the presence of an oxidizing agent, and in this case the hydrogen sulphide water is not strong enough to do its part and should be strengthened by bubbling more gas through it. The other cause for a green color is the presence of iron, which has gotten in the solution through contamination. This sometimes can be traced to the hydrogen sulphide water, too, as often the wash water for the gas generator bubbles over into the receiving bottle or iron may run through or over the edge of the filter paper in filtering, and thus gets into the filtrate.

Too high results are more apt to be obtained on high titrations over 40 per cent than on lower ones, due to an accumulative error because of titrating too rapidly.

For titrating the volume of the solution should always be the same. This is important, as well as the acidity and the amount of salts in solution. Use the same size drop, both of the indicator and the solution to be titrated, retaining the same conditions of spotting on the ore as were used on the standard.

There is one criticism I should like to make of the scheme given by Low,⁶ and that is in regard to standardizing. Low does not allow for the same amount of salts in solution in the standard as for the ore, and consequently, on 40 c.c., the standard runs 0.7 c.c. higher than if it was run through like the ore, thus making the determination of zinc 0.7 per cent too low in this particular case.

The standard solution contains 21.54 grams potassium ferrocyanide per liter, and 1 c.c. equals 0.005 gram of zinc or 1 c.c. equals 1 per cent on a 0.5-gram weighing.

The equation for the precipitation in an acid solution is evidently different from that in an alkaline solution, for the latter standard solution requires 16.25 grams potassium ferrocyanide per liter. The reason being that in an acid solution the precipitation is a potassium zinc ferrocyanide and in the latter a normal zinc ferrocyanide.

The method adopted by the American Chemical Society is as accurate as the one described, but not so simple or convenient in the manipulation. In the alkaline titration analysts have experienced trouble in getting a definite end point on the standard which holds good for the subsequent titration of the ore analyses. One scheme described even going so far as to insist on a standard being run with each set of twelve determinations, since the end point varied with the eight. Using Low's method there is no such trouble with the end point if a 5 per cent uranium nitrate solution is used, kept in an amber-colored glass bottle.

In the use of a method for determining zinc in an acid solution without the addition of hydrogen sulphide

⁴Ostwald's Scientific Foundations of Analytical Chemistry, 1895, Chap. Page 18.

⁵Miller, Chemical Analysis, 1904, Chap. IX, page 67.

⁶Methods of Ore Analysis, 1913. Chap. XXX, page 284.

water before titration, the chlorine apt to be produced gives high results.

Of the metals that interfere, manganese has been accounted for; copper is precipitated by the hydrogen sulphide water. Small amounts of cadmium are not precipitated by the latter. On a standard made up of 200 grams zinc and 0.015 gram cadmium sulphide, the result was 0.22 c.c. too high, equivalent to titrating an ore running 40 per cent zinc and about 2 per cent cadmium. Cobalt and nickel interfere, but are not found in the ordinary zinc ores of commerce. Acknowledgement is due Mr. J. W. Richards of Denver for many helpful suggestions.

Donora Zinc Works,
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Hydro-Electric Power and Electrochemistry and Electrometallurgy in France

By C. O. Mailloux, E. E., D. Sc.

(Member of the American Industrial Commission to France).

(This article contains the notes which were prepared by Dr. Mailloux to furnish information for the editors of the Report of the American Industrial Commission to France. A brief abstract of the first portion only, relative to hydroelectric power, was published in the Report. The second portion, relating to Electrochemistry and Electrometallurgy, has not yet appeared in print. The present installment contains the complete text of the first portion, and the complete text of the second portion will appear in a subsequent issue.—Editor.)

There is abundant evidence that the importance and value of hydro-electric power (the power generated by water and transmitted to and distributed at distant points by electricity) are thoroughly understood and appreciated in France. There is, indeed, no country in the world today where steps have been taken for such a comprehensive and exhaustive study of all the water powers available in the various parts of the country. This makes a somewhat detailed reference to the subject of considerable interest.

The art of utilizing water power and of transmitting energy to long distances by electricity is one in which France was a pioneer and a leader, and in whose development she has taken and is still taking an important part.

On the one hand, the possibility of obtaining power from the energy available in the water of mountain streams is of great interest to a country which, like France, produces only a portion of the fuel it consumes, and has to supplement its own production by importing large quantities of coal from other countries. Before the war the annual coal consumption in France was, in round numbers, 60,000,000 tons, of which amount about 40,000,000 tons were obtained from French coal mines, leaving a shortage of about 20,000,000 tons to be made up by importation from other countries.

On the other hand, there are numerous places where water power can be developed in considerable amounts in the mountainous regions of France, in the Northern and Southern French Alps, in the Vosges and Jura Mountains, and in the Pyrenees. The aggregate of this power is estimated at from 6,000,000 to 10,000,000 hp.

It is estimated, from statistics in regard to steam power in France, that about 75 per cent of the total coal consumed, or about 45,000,000 tons, is used for producing steam for generating mechanical power, aggregating about 12,000,000 hp. This corresponds to about 3,750,000 tons of coal per year for each million hp. of steam power capacity, so that the full development and utilization of 6,000,000 hp. of water power would, theoretically, more than make up for the entire coal shortage in the whole country.

The American Industrial Commission to France had the privilege of visiting the very interesting region where water power abounds—the so-called "white coal region" ("région de la houille blanche")—in the eastern

part of France, on the western slopes and watersheds of the Alps, and the Jura Mountains, where French scientists and engineers found both the incentive and the opportunity for the wonderful pioneer work done by them in hydro-electric power development and power transmission.

Evolution of Water Power. Before 1827 the only forms of water motor in general use in the world were the old-fashioned "waterwheels," now of historic or pictorial interest only, and seldom to be seen elsewhere than at some old-time grist-mill or in some picture of by-gone periods. These waterwheels were of small power capacity, in spite of their large size; they were not at all suited for the development of power in great amount from large and high water falls. There was a limit not only to the diameter that could be given to them, to adapt them to falls of greater height, but also to the length that could be given them, to adapt them to an increased volume of water from large streams. An idea of the inherent limitations thus imposed on the power capacity attainable with waterwheels of that now obsolete kind may be obtained from the best examples of such wheels, such as from the four remarkable breastwheels, each 50 ft. in diameter, said to be the largest in the world, erected at Catrine in Ayrshire, Scotland, by Sir W. Fairbairn in 1825. These monster wheels, a monument to the boldness of their designer, are still working; but as the capacity of each is only 125 hp., there is no likelihood of their serving as models for modern water motors. More than 1000 times that power capacity can now easily be put into the same space with a modern water motor.

The efforts made to devise a water motor more satisfactory than the old-fashioned waterwheel date from the year 1827, when a prize was offered, in France, by the Société d'Encouragement for an improved water motor. The modern type of water motor known as the "turbine" owes both its origin and its name to that offer. The prize was awarded to Fourneyron for his celebrated water motor, the first hydraulic "turbine." The wonderful perfection of this invention is sufficiently shown by the fact that the Fourneyron turbine is still being made extensively today, with but little modification in design. Moreover, Fourneyron had made such important contributions to the problem of securing proper speed regulation and high efficiency at varying loads and with varying amounts of available water that most of his methods and expedients for attaining these objects are still utilized in many cases.

Fourneyron's invention led to a rapid development in water motors of the turbine type, as the result of which it became possible to produce water motors of greatly increased power capacity, occupying much less space, and, especially, to use such motors for developing power from water falls of much greater heights and volumes than had been hitherto possible. The development of turbines suitable for producing large amounts of power, especially from high waterfalls, however, was slow. The reason is that for more than 50 years after the advent of the turbine there was little, if any, demand for such turbines. During all that time the only method of power transmission known to the world was that of mechanical transmission by means of shafting and belting, to very limited distances, and in limited amounts. Under such circumstances it was necessary either that the power should be developed very near the works where it was utilized, or else that the works should be located very near the place where the power was to be developed. In most cases turbines of large power and suitable for high heads were not necessary. It was more practical to use a greater number of smaller turbines. In the majority of cases no attempt was made to utilize either the full flow or the full head of the



stream. The result was that usually a great portion, often the greater portion, of the available power was not utilized.

As is well known, it was only after the advent of electric power transmission that there arose a demand for large prime movers for both water and steam power. Even as late as 1875 a hydraulic turbine or a steam engine of 300 or 400 hp. was considered a very large power unit. It is noteworthy that one of the "world wonders" at the Centennial Exposition in Philadelphia in 1876 was a pumping engine of 1000 hp., designed by Corliss, the great American engine builder. At that time this was considered, even by engineers, a unit too large to be practical. Even in spite of the advent of the direct-coupled engine-driven dynamo, which made a demand for larger steam engines, the largest unit at the Chicago Exposition in 1893, or seventeen years later, was barely 1000 hp. At the present time hydraulic turbines of 20,000 hp. and steam turbines of 75,000 hp. are no longer considered marvellous.

The highest development and the most important applications of hydro-electric power generation and transmission have resulted from progress in two important respects, namely, increase in the height or head of waterfall utilized for producing power, and increase in the electrical pressure or voltage utilized on the electrical transmission line. It is worthy of note here that these two features were first suggested and tried in France, in the very region visited by the commission.

High Head Hydraulic Turbine. Efforts to develop the hydraulic turbine in order to adapt it to very high heads were made by the original inventor himself, Fourneyron, as early as 1840, and again, later, in 1850, by another prominent French hydraulic engineer, Gérard, the inventor of the turbine of that name. The highest falls to which these men attempted to adapt turbines are said to have been of "over 100 meters" (328 ft.). The practical results do not appear, however, to have been entirely satisfactory. It was recognized that the hydraulic turbine would need to depart considerably from the standard types of Fourneyron and Gérard, in order to meet the requirements for high heads. The "reaction" type of turbine had been highly developed; but the "impulse" type needed further development. This was also realized in America, especially in mining work, where it is desirable to utilize streams of small flow and of high heads as sources of power. Attempts to solve the problem of obtaining power from waterfalls of high heads were made in America in the mining districts in California, beginning about 1860, which resulted in the construction of primitive "impulse wheels," known as "hurdy-gurdy wheels," carrying vanes against which jets of water were directed. The evolution of this "hurdy-gurdy" water motor led, in time, to the invention of the Pelton wheel. Some of these "hurdy-gurdies" were used with heads as high as 2100 ft. (640 meters). No attempt seems to have been made, however, to produce large power units, the largest sizes used being of only 100 to 125 hp.

A most interesting contribution to the evolution of the turbine was the invention, in 1867, of a new, highly practical and efficient form of "impulse turbine" by M. Aristide Bergès, a French engineer, proprietor of a large factory devoted to the manufacture of paper and woodpulp, located at Lancey (Department of Isère) near Grenoble.

M. Bergès in 1867 attacked the problem of utilizing the power obtainable from a nearby waterfall of 200 meters (656 ft.) as a source of mechanical power for his woodpulp works. His experiments and tests led him to design and construct a turbine of entirely new and very original type, which was put in permanent opera-

tion, giving satisfactory service, in 1869. This turbine, which is now preserved in a museum at Lancey, furnished power for grinding wood to make woodpulp fibre. It utilized the full head of the fall (200 meters, or 656 ft.). In 1873, after this turbine had been giving satisfactory results for four years, M. Bergès installed a second turbine, designed to utilize the water from a fall of 500 meters (1640 ft.). This turbine was remarkable, not only for the high head under which it could operate, but for the great power that it could develop (800 hp.), which entitles it, perhaps, to rank among the largest hydraulic turbines of that period. It was moreover remarkable, in fact epoch making in still one more respect, namely, that, as a hydraulic turbine of the "impulse" type, its design, construction and operation embodied substantially the same principles as appeared from twenty to twenty-five years later in the steam turbine of the "impulse" type; so that a person skilled in the art of designing steam prime movers, and properly informed in regard to the difference in physical properties and characteristics of the two "fluids" used, namely, water and steam, should have been able to evolve a satisfactory type and form of steam turbine from the Bergès hydraulic turbine. In the next few years other turbines were installed at the paper works, until the stream utilized, a small mountain brook, coming down from the glacier, which originally supplied only a nominal amount of power (not over 50 hp.), was supplying 2000 hp. to the works, besides furnishing power for generating electric current used for lighting in the surrounding villages. M. Bergès estimated, at the time, that the power made available by his efforts (about 3000 hp.) could be practically trebled by developing power higher up on the stream, so as to utilize the entire head. This more complete development of the stream is now in process of being carried out; so that M. Bergès's dreams of power development in Lancey and vicinity are coming true. At the 1889 exposition in Paris, M. Bergès exhibited one of the early turbines made by him, and he announced the fact that he was at that time designing a turbine equipment for developing power from a fall of 1718 meters (5635 ft.). This is perhaps the highest head that has been proposed for utilization by means of any form of water motor. A "tour de force" of this character was not an impossibility with the Bergès type of "impulse" turbine.

The American Commission visited the Bergès Works at Lancey by invitation, and saw several Bergès turbines in operation, including one installed over 40 years ago, which was still doing satisfactory service.

High-Voltage Electric Transmission. It happened that the vicinity of Grenoble was the scene of the first scientifically conducted tests of long-distance electric power-transmission. Those tests, which were made at different periods between 1880 and 1883, were conducted by an eminent French physicist and engineer, M. Marcel Deprez, for a syndicate of French capitalists. Their purpose was to determine, by practical trial, under diversified conditions, the amount of power which could be transmitted, the losses of transmission, the limitations as to distance and commercial feasibility, and, incidentally, to find ways of improving the apparatus used and the results obtained. The transmission line used extended from Grenoble to Vizille, a distance of about 20 kilometers. By making loops and detours in the line the transmission-distance could be increased to 50 kilometers or more.

These tests were epoch-making in many respects, but their greatest value was in demonstrating the importance of high voltage as a factor of economy and of commercial success in electric power-transmission. They pointed out the direction in which improvements

in methods and in apparatus must be sought in order to make success possible.

Distribution-System. While economy of transmission dictated the use of the highest possible voltage on the transmission-lines, the conditions attending the distribution of electric power at the receiving end of the transmission-line, and the necessity of avoiding all danger of harm to persons and property, introduced new problems, calling for means of reducing the voltage of the electric current "distributed" to the consumers. This was furnished by the development of the "transformer" during the last decade of the nineteenth century. This period marks the beginning of the rapid development of hydro-electric power in all parts of the world.

"White Coal." The term "houille blanche," meaning literally "white coal," for designating the power obtainable from the melting ice and snows of glaciers, is said to have originated with Cavour, the Italian statesman, but it was introduced and made popular in France by M. Bergès, the inventor of the high-head hydraulic turbine. He originally employed this term to designate all streams which are fed and regulated by glaciers, because the solidified water in the form of ice and snow in this glacier represents stored energy available for power, similar to the stored energy contained in ordinary ("black") coal. The energy available in streams not fed by glaciers was termed "green" coal ("houille verte"), because the energy comes from water stored in green vegetation. The expression "white coal" has, however, gradually enlarged its meaning, and it now means the energy of any waterfall that is available for developing water-power; therefore it now practically includes "green" as well as "white" coal, although the term "green coal" is still occasionally used.

"White Coal" Congresses. In September, 1902, a "white coal" or water-power congress was held at Grenoble, which was a great success. From statistics presented at that congress it appeared that the water-power already developed at that time, in France, aggregated about 200,000 hp. With a view to stimulating the development of water-power in all parts of France a resolution was adopted, requesting the Government to take steps to make a survey of the available water-power of France. In 1903 the Government took action by creating a commission for large water-powers, which was entrusted with the work of estimating the hydraulic resources of France. This commission has already studied a certain number of the basins in the Alps and in the Pyrenees, from the geographical, meteorological and hydrographic points of view. The results of these researches are published regularly. Six volumes have already appeared for the Alps and two for the Pyrenees. The commission has also published some very useful maps, giving information and data regarding the hydro-electric plants in the region of the Alps. One of these maps gives the locations of electric generating plants and the transmission and distribution systems up to 1912; another map, just issued (1916), gives the fullest and most recent information about the location and capacity of the principal water-powers and the work for which the power is used in the region of the Alps. (See map, page 266).

A second water-power congress, organized by an association of water-power owners, was to have been held at Lyon in September, 1914. It was, of course, postponed. It will likely be held soon after the war is over. The rapid development of water-power in France will doubtless make these congresses recur at shorter intervals in the future.

Water-Power Association. As in the case of all large industries in France, the water-power industry has its

interests looked after by a "get-together" organization, having a very comprehensive name, which includes all concerns interested in water-power, electrometallurgy, electrochemistry and "all the industries related thereto." The association is really composed of three distinct groups of industries, each of which has its council or board of directors; the first group, composed of concerns engaged in "electric power transmission and distribution," contains 54 member-companies; the second group, composed of concerns engaged in "electrometallurgy and electrochemistry," contains 24 member-companies; the third group, composed of "sundry and miscellaneous concerns," contains 30 member-companies. There is a general council, of not less than 12 nor more than 35 members, elected at the annual meeting from representatives of all three groups of member-companies. Continuity of policy in the council is secured by electing the members of the council for three years and changing only one-third of the total number each year. The council members elected from each group of member-companies also form, by themselves, a corresponding "section" of the council. Each of the three sections of the council must meet at least six times each year to consider matters of special interest or importance to that section. Its decisions and resolutions are subject to approval and review by the general council. The statutes (by-laws) of the association are similar to those of other French industrial associations or syndicates. They are a model of their kind. A practical means of securing co-operation and exchange of information and ideas between this and other similar industrial associations is to have the same person serve them all in the capacity of general secretary. His office is the information bureau for all the associations and their various sections, and he is the connecting link between them all. They all have their headquarters and hold all their meetings at the same place. Their co-ordination is remarkably complete and perfect, and they can co-operate for accomplishing a common object, on occasion, in a most prompt and efficient manner.

Available Water-Power. The work done by the Water-Power Commission, since it was organized in May, 1903, enables a fairly close estimate to be made of the water-power available in the region of the Alps, but it is still difficult to make any estimate of the water-power available in the rest of France. An official estimate made under the direction of the Water-Power Commission five or six years ago gives the following approximate figures:

	Low Water Flow, H.P.	Average Water Flow, H.P.
Northern Alps (Haute Savoie, Savoie Isere, Hautes Alpes)	1,000,000	2,000,000
Southern Alps	1,300,000	2,600,000
Central Alps, Vosges and Jura Mountains	900,000	1,800,000
Pyrenees and elsewhere	1,400,000	2,800,000
Total	4,600,000	9,200,000
Another, more conservative, estimate gives an aggregate of 4,500,000 hp. for low water, and 6,000,000 hp. for mean water.		

Capacity Developed. The official annual (1914-1916) report of the French Water-Power Association, already mentioned, states that the aggregate power-capacity of all the water-powers owned or exploited by the various power companies belonging to that association is 660,000 hp.. Of this total, 412,000 hp. represents power transmitted and distributed for general lighting and power purposes in cities, towns and villages; the rest (248,000 hp.) is power consumed by electrometallurgical and electrochemical industries. The distribution-systems owned by the power companies belonging to the association constitute a network of 16,200 kilometers (10,066 miles), of which 13,400 kilometers (8325 miles) are overhead lines and the rest (2800 kilometers, or 1740 miles) are underground lines. These distribution-

systems serve to supply electric current for light and power to communities aggregating between four and a half and five millions of inhabitants.

The capital investment represented by all these plants exceeds 600,000,000 francs.

The greater number of these plants are located in the region of the Alps. As there are also many water-powers, both in the Alps and elsewhere, which are operated by companies and individuals who are not members of the Water-Power Association, the preceding figures for power developed are presumably too low for the whole of France. According to statistics prepared by the French Water-Power Commission, the total installed power-capacity in the eastern regions alone exceeds the total given above. The official figures, for Dec. 31, 1915, as reported by the commission to the Government, show the following results:

Hydraulic Power-Capacity Installed in the Region of the Alps

	H.P.	% of Total
Power used for light and power.....	291,000	39.4
Power used for electrometallurgical works.....	255,000	34.6
Power used for electrochemical works.....	147,000	19.9
Power used for electric traction.....	16,000	2.2
Power used for paper mills, saw mills, etc.....	23,000	3.1
Power used for various industries (lime and cement works, spinning, etc.).....	6,000	0.8
Total.....	738,000	100.0

These figures agree substantially with those given on the map issued, as already stated, in 1916, by the Water-Power Commission.

Of the above total, the basin of the Isère River furnishes 427,000 hp. and the basin of the Durance River furnishes 112,000 hp., the rest (199,000 hp.) being furnished by the basins of the Rhone and other streams.

The 1916 map gives the following additional information for the same region:

Power-plants under construction or for which contracts have been made.....	100,000 hp.
Water-powers whose development is contemplated or proposed.....	700,000 hp.

The American commission saw evidence of great activity in further developments of water-power, many of them of considerable magnitude and importance, at various points in the "white coal" district. The members were given the opportunity to see several power-sites where the construction of dams, intake and discharge canals, power-station buildings, transmission-lines, etc., were under construction.

In addition to the projects now in process of realization there are many more that are in contemplation for the future. The pioneer work of Bergès has borne fruit in the development of the impulse turbine for high heads, and of large power-capacity. There is no longer any hesitation to utilize falls of 1000 to 2000 meters (3280 to 6560 ft.) in height, in one station, instead of doing it in a number of steps or stages, with a dam and a power-station at each stage, in order to reduce the working head and pressure at each stage, and turbines of 10,000 to 20,000 hp. are coming into use. The highest fall developed in France up to the present is at Orlu on the Argeège River, where the fall is 940 meters (2983 ft.).

The two most important water-power projects are those known as the "Durance" and the "Upper Rhone" projects.

Durance Project. This project is aimed at the utilization of the water of the Durance River in the south-eastern part of France, at a point about 200 kilometers (124 miles) from Marseilles. The project is in the hands of a syndicate known as the "Société pour la régularisation de la Durance," composed largely of people who are already interested in many of the large water-power companies owning plants in the region of

the Alps. The head of the syndicate is the managing director of the companies already owning and operating the largest water-powers in that region, including one on the Upper Durance of 30,000 hp. and one in the Mediterranean Coast region of 32,000 hp., and he is a director in seven other companies operating smaller plants, the aggregate of all the plants being a power-capacity of over 110,000 hp., representing a capital investment of over 140,000,000 francs. From this it will be seen that the Durance project is in the hands of competent, experienced persons. The dam will be located at Serre-Ponçon. It will have a height of 85 meters (279 ft.) above mean low water, and of 127 meters (417 ft.) above the rock-foundation. The storage-reservoir produced by this dam will hold 600,000,000 cubic meters of water. This will enable the flow of water below the dam to be regulated so as to secure minimum steady flow at the following rates:

During six autumn and winter months, 50 cubic meters (13,210 gal. per second).

During three spring months, 65 cubic meters (17,173 gal. per second).

During three summer months, 75 cubic meters (19,815 gal. per second).

The power available with these quantities of water will range from about 70,000 hp. in summer down to somewhat less than 50,000 hp. in winter. The power-station, which will be installed near the dam, will comprise eight units of 10,000 hp. each. The greater portion of this power will be utilized for electrochemical products, especially for making cyanamide and other nitrogenous substances, and also for electrometallurgy. The estimated cost of this power-development is 36,000,000 francs.

Upper Rhone Project. The Rhone is the outlet of Lake Lemman (sometimes called the "Lake of Geneva"), which constitutes an enormous storage reservoir for that river. In the Swiss portion of the Upper Rhone, extending from Geneva to the French frontier, a distance of about 18 kilometers (11 miles), the city of Geneva itself has been active in developing water-power. It began as far back as 1713, when the hydraulic power of the Rhone was utilized to furnish power for pumping water for the city of Geneva. The old water-pumping station, after undergoing innumerable repairs, extensions and improvements, during a period of nearly two centuries, was finally replaced by a new, modern water-pumping station, begun in 1883, and finished in 1887, which was, and remains, the model of its kind. The world-wide interest excited by this plant was largely responsible for the appointment of its designer, the late M. Turettini, later Mayor and Commissioner of Public Works of the City of Geneva, as one of the members of the commission of eminent scientists and engineers that outlined the plans for water-power development at Niagara Falls.

The dam serving for this pumping-plant also serves for the very important purpose of regulating the flow of water from Lake Lemman into the Rhone, so as to keep the level of that lake within certain limits, the extreme variation allowed at any time between highest and lowest levels being only 60 centimeters (about 2 ft.). The hydraulic power developed at that station is about 6000 hp. Another interesting feature of this plant, which deserves mention here, is that the water pumped at this station and sent into Geneva was used considerably, and is still used to some extent, in Geneva for driving water-motors; so that, in effect, the problems of power-transmission and distribution were solved here in an original manner, and with some success, *hydraulically*, several years before the problem was solved *electrically*.

Between 1893 and 1896 the city of Geneva built another larger water-power plant further down stream, below the point where the Arve River empties into the Rhone. This station is a hydro-electric station; the whole of the power developed (about 12,000 hp.) is used for driving electric generators; none of it is used for pumping.

A third station, under construction, still further down stream, will develop about 18,000 hp., and, eventually, there will be a fourth station of about 8000 hp. From what precedes, it is seen that the power already developed and available for future development, in the Swiss portion of the Rhone, aggregates over 50,000 hp.

On the French side of the frontier, the Rhone runs through deep gorges and over many falls, which, in a distance of 23 kilometers (14.3 miles) from the frontier, make an aggregate drop of from 67 to 69 meters (220 to 226 ft.), according to the time of the year. This drop, if produced at one point by a dam, would be considerably higher than Niagara Falls, which is less than 200 ft. The volume of water, which is already increased by the water emptied into the Rhone by the Arve, near Geneva, is still further increased by the water of a second stream, the Valserine, which empties into the Rhone at a point about 15 kilometers (9.3 miles) below the frontier.

The mean flow of the stream, at Genissiat, a place situated 23 kilometers (14.3 miles) from the Swiss frontier, is about 300 cubic meters (79,260 gal.) per second. The utilization of this volume, with the full drop, taken at an average of 68 meters (223 ft.), would represent a useful power of over 200,000 hp. It would seem, therefore, that this portion of the Rhone presents the opportunity for one of the largest water-power developments in France.

The possibilities of the French Upper Rhone as a source of water-power attracted attention as early as 1871, or long before electric power-transmission was even dreamed of. At that date, an English company obtained authority to build a water-power plant on the Rhone at Bellegarde, about 14 kilometers (8.7 miles), from the Swiss frontier, with the right to utilize an average fall or drop of about 12 meters (39.4 ft.), and a volume of water of 60 cubic meters (15,852 gal.) per second, which was estimated to represent a useful power-capacity of about 6400 hp. The originators of the project intended to transmit power *mechanically*, by means of long belts made of rope or cable, running over large sheaves, as had been done to some extent in England. Those "rope-drive" transmissions of mechanical power were to serve for distributing the power produced at the power-station to various factories and works located in the immediate vicinity of the station. This scheme, which was without doubt the largest and boldest scheme of power-transmission and distribution of that period, was a financial failure, because there was not enough demand for the power thus made available to make the enterprise pay. The power-plant eventually passed into the hands of another company, and it lay practically idle until interest in it was revived in the late nineties, after the problem of power-transmission had been solved by the aid of electricity.

Various projects have been proposed in recent years for the development of water-power on the French Upper Rhone. One project is based upon the plan of utilizing a fall or drop of about 20 meters (65.6 ft.), which would mean a power-capacity of 20,000 to 40,000 hp. Another project aims at the utilization of a fall of 21 meters (68.9 ft.), which would give a somewhat increased power-capacity. Reference will be made, in some detail, to a third plan, which aims to utilize, by means of a single dam and at a single power-station, the whole of the energy obtainable from the stream be-

tween the Swiss frontier and the village of Genissiat, situated 23 kilometers downstream. This project was worked out by three distinguished French engineers, Messrs. Blondel, Harlé and Mähl, in 1905. As their plans contemplated the transmission of energy by electricity from this plant to Paris, a distance of 450 kilometers (279 miles), a "White Coal Commission," composed of 31 members, including the most distinguished civil, electrical and mechanical engineers in France, and also including many able scientists, economists and men of affairs, was appointed by the Prefect of the Seine to make a full inquiry into and to report upon the feasibility and merits of the project. This commission rendered a favorable report in 1908.

In 1909 a syndicate was formed to make a complete detailed study of the technical, engineering and financial features, and to work out the more important details of the project. The work of this syndicate, which included the thorough exploration of the region, by borings, soundings, etc., was completed in the early part of 1912. The plans for the project are very complete, and they show that the work of their preparation received the most exhaustive and thoughtful study, and that it was done with great care and thoroughness, with the desire to work out the most minute details and to anticipate all difficulties and meet all objections. The two principal difficulties incidental to this proposed water-power development are: First, the sudden freshets, occasionally of flood-like character, due not to the water from Lake Lemane, whose flow is regulated and controlled by the city of Geneva at the pumping station, as already stated, but to the waters of the two tributaries, the Arve and the Valserine, which discharge into the Rhone above the proposed dam-site; second, the alluvial deposits resulting from matter eroded and then deposited by the stream at places where the current is slow. The engineers have anticipated these difficulties and have made adequate provision against them.

A few figures taken from the reports of the authors of the project will suffice to give a general idea of the project. The plans contemplate a dam at Genissiat of stone and armored concrete of 76 meters (249.3 ft.) in height, which will dam up the water to a head of 69 meters (226 ft.) in the low water season and of 64 to 65 meters (210 to 213.3 ft.) in season of high water. This will raise the stream level above the dam high enough to fill the gorges of the Rhone as far up stream as the Swiss frontier, thereby making a lake of 23 kilometers (14.3 miles) in length, which will constitute a large storage reservoir for the power-station, with a capacity such that, by allowing the level to fall 4 meters (13.1 ft.) a water reserve flow of 15,000,000 cubic meters (nearly 4,000,000,000 gal.) can be obtained, which, with the lowest head (64 meters) would represent a supply of energy of not far from 1,000,000 hp.-hours. The average power available will range from a minimum of 80,000 hp., in the low-water season, to 320,000 hp. in the high-water season; and even in the low-water season the storage reservoir will enable the plant to carry a "peak-load" of 160,000 hp. It is interesting to note that while the dam will be of lesser height than that required for the Durance project, the total power developed will be very much greater.

It is proposed to transmit electrically to Paris a portion of the energy obtainable from this plant, using three-phase current of 25 periods, at a pressure of 120,000 to 140,000 volts. The voltage will be reduced, near Paris, to a suitable voltage (about 15,000 volts) for distribution to large power consumers; and it is also proposed to use apparatus for changing the frequency and otherwise adapting the current for lighting and other requirements. A considerable portion, perhaps the greater portion, of the power developed would be

distributed at various places much nearer the power-station than Paris. The engineers assert that, since the plant will find a market for its power at all points along the whole way to Paris, there will be no difficulty in disposing of the entire power output of the plant at all times. The total cost of this development will range between 130 and 160 million frs., depending upon the extent of the transmission and distribution system.

The very magnitude of this project made it seem somewhat utopian in a country like France as it was before the war, whereas it would not have seemed so stupendous even for France, in the eyes of American engineers and capitalists, who are more accustomed to large power projects. The enormous activities in mechanical industry which have resulted from the war, and the consequent great demand for power, so sudden and so hard to meet, which occurred, have unquestionably caused a great change in opinion and in attitude, in France, on the subject of power-supply, especially since the price of coal has risen to such extraordinary figures. The project would presumably look far more attractive to-day to financiers than it did five years ago; and it is possible that some of them now regret that they did not then show more interest in it.

The estimated annual output of useful energy from this plant is 1,300,000,000 kw.-hr. To produce the same energy by steam power 1,800,000 tons of coal would be required. Allowing 25 francs per ton, the present minimum price for domestic French coal, the value of the yearly output of the plant would be 45,000,000 francs. This would be equal to 15 per cent of 300,000,000 francs of capital investment. We may say, therefore, that this is what the plant would have been worth to-day. It would not have cost anywhere near that sum. Of course, if a part of the coal which the plant would have eliminated is taken at the cost of imported coal, then the financial results are even more impressive.

There is very little reason to doubt that this important water-power development will be made some day, perhaps in the near future.

Pyrenees and Elsewhere.—Although a considerable amount of water-power has already been developed in this region, there is still much to be done there. The lack of market for power has been the principal drawback. It may prove possible there, as it has in the "white coal" region of eastern France, to develop electrochemical and electrometallurgical industries which would utilize a great portion of this power. This is in the minds of many people in France, and some initiative in that direction may result before long. Now that it has been demonstrated in America that very high transmission-voltages (100,000 to 140,000 volts) are practicable, the radius of territory which can be reached and served by long-distance electric power is so much increased that even places like Bordeaux come within the range of the power obtainable from the Pyrenees. A great increase may be expected in the amount of water-power developed in the region of the Pyrenees in the next few years.

A certain amount of hydroelectric power is already obtained from the Dordogne River, at Tuiliere, near the point where that river empties into the Garonne, some 40 or 50 miles east of Bordeaux. The "Southwest Power Company" which operates this plant—from which power is sent as far as Bordeaux itself—has in contemplation other hydroelectric developments farther upstream on the Dordogne which, it is expected, will bring the total power from that river up to at least 50,000 hp. There is therefore, a good prospect that Bordeaux will have, in time, a good supply of cheap electric power.

The streams in the hills of Normandy and Brittany

if properly developed under modern methods can be made to yield power in small amounts, which, however, would be only of local interest and importance.

Outlook and Prospects.—The water-power industry is one which is generally regarded in France as having earned the right to be encouraged and fostered by both the public and the government. The plans in process of execution and in process of preparation indicate that the aggregate power developed in France will reach 1,500,000 hp. in the next two or three years. This will be still less than one-third of the estimated total power available during the periods of lowest water; yet it will be the equivalent of five or six millions of tons of coal per year that would otherwise have to be provided to do the same work, and which would become an item of the coal shortage that has to be made up by importing coal from other countries.

Irrigation.—In America, water power developments are frequently identified with irrigation projects; indeed, they are, sometimes, merely incidental to such projects. In France, where the soil is not arid to any extent, the utilization of water for irrigation purposes is of secondary importance, in comparison with the development of power. Nevertheless, in certain regions, notably in the southern districts, in Provence, irrigation is capable of producing great results. Its possibilities are kept in view and the uses made of it will increase greatly in the near future. There is interesting work to be done there by the irrigation engineer in adopting the plans and methods which have proved successful in the arid regions of the United States.

Growth of Electric Service.—The existence of nearby and cheap sources of electric current-supply in the "white coal" region has made itself evident in facilitating and increasing the use of electricity for lighting and power in the towns and villages of the region itself, and also of neighboring regions. In many places the low cost of electric current has made it possible for even the farmer to utilize it for lighting and power, to lighten his tasks and increase his comforts. Even stables have been lighted by electricity; and the cattle has had better care, in consequence. It is stated that the supply of electric light in the farming communities has led to the increase of profitable reading and study on the part of the inhabitants, producing a cultural effect of much value, and that it has also had a favorable influence on the development of agriculture by facilitating the desire and efforts of the farmer to add to his knowledge and to improve his situation.

The facility with which the power can be distributed to families and small workmen's associations has led to the establishment of small home factory plants, not only in the village communities but even in cities like Lyons and St. Etienne and similar industrial sections, in this way giving a new impetus to home industry to counterbalance the concentration of many hands in large factory plants.

It is not in the small communities alone that there has been a great increase in the use of electricity. Indeed, one of the most striking examples of such increase is to be found in the city of Lyons, the third largest and the most important industrial city in France. The manner in which the consumption of electrical energy has grown in that city, as traced by the statistics, is very remarkable, and also very instructive, as showing how greatly reduction in the cost and improvement in the quality of service may stimulate the consumption.

The total electrical energy consumption in kilowatt-hours, supplied by the electric plants of the Lyons Gas Company, has increased from 399,100 kw.-hr. in 1897 to 35,400,000 in 1915, or, at the end of eighteen years, it was over 90 times greater. Surprising as this growth

is, there is still greater surprise in finding that 88 per cent of it occurred in the last five years of that period. Up to 1910, the annual increase in number of patrons or in total consumption was low; and the curve of growth, obtained by plotting the yearly totals of customers or of consumption, flattened out in a way that would have led any statistician to believe that the maximum of electrical consumption had been practically reached and that this maximum would probably not exceed 4,000,000 kw.-hr. per year. In April, 1910, the company made an important reduction in rates, in anticipation of the completion of its new power station, then under construction, and which was put in operation in 1911. The effect of these measures on the number of customers and on the total consumption was apparent in the total consumption for 1910, which showed an increase equal to that noted during the four previous years; and it became marked in the totals for the year 1911, which showed an increase as great as that which had occurred in the thirteen years preceding. In 1912 and in 1913 the growth in consumption was still greater (from a total of 7,000,000 to 16,500,000 kw.-hr., or an increase of more than 100 per cent in these two years). At the end of 1913, the total consumption was, in round numbers, four times larger than it was at the end of 1910. At the end of 1915 the total consumption was over eight times that for 1910, and five times that for 1911.

Cost of Electrical Energy.—The rates which went into effect in Lyons in 1910 fixed the cost of current, per kilowatt-hour, at 60 centimes for domestic lighting, at 55 centimes for stores, offices and factories, at 50 centimes for hotels, cafés, restaurants, theaters, churches, schools, etc., and at 40 centimes for small power consumers. Discounts were to be allowed as follows:

Amount of Discount	Lighting Current	Small Power Current
2 per cent on bills of.....	100 frs.	25 frs.
5 per cent on bills of.....	250 frs.	100 frs.
10 per cent on bills of.....	500 frs.	500 frs.
15 per cent on bills of.....	1,000 frs.	1,000 frs.
20 per cent on bills of.....	1,500 frs.	1,500 frs.
25 per cent on bills of.....	2,000 frs.	2,000 frs.
30 per cent on bills of.....	2,500 frs.	2,500 frs.

There was also a "flat" rate, per annum, for incandescent lamps. This rate varied with the kind of lamp, its candle-power, and the number of hours per day that it was to burn. For large power-current consumers there were special rates, either by meter, or else "flat," by the year. The meter rates, in centimes per kilowatt-hour, ranged from 20 for motors of 1 hp., to 16.5 for motors of 10 hp., to 13.8 for motors of 20 hp., to 12.5 for motors of 30 hp., to 10.9 for motors of 40 hp., and to 9.5 for motors of 50 hp. For still larger motors, the rates were further reduced; the lowest rate for motors working during "off-the-peak" hours, such as at night, is 5 centimes per kilowatt-hour. These prices have had to be increased since the war, on account of the high cost of coal. There is, indeed, no special desire at the present time, to induce the consumers to increase their consumption, but rather a desire to have them do the opposite, because there is so much more power needed than usual for works producing war munitions and supplies.

In a large munition works, visited by the commission, in Lyons, where the electric motors installed aggregate about 6000 hp., the electrical energy supply required is derived from two different systems of distribution. The amounts of electrical energy consumed for lighting are metered separately from those consumed for power in both cases. The cost of lighting current is the same in both cases, 20 centimes per kilowatt-hour (equivalent to about 4 cents, before the war, and to less than 3 cents with present rates of exchange). The cost of the

power current is different in the two cases; in one case it is 6.5 centimes (about 1.3 cent) for night work, and 7.5 centimes (about 1.5 cent) for day work, or an average of 7 centimes; in the other case, the average cost is about 15 centimes (about 3 cents) per kilowatt-hour, or more than double the cost of current from the first system. The total number of employees in the works was between 11,000 and 12,000, working in two shifts per day of 24 hours. The bills for electric current averaged about 2500 francs per day. The cost of electrical energy for lighting and power is kept separately for each department of the works. In the department devoted to the manufacture of 75 mm. shells the cost of electrical energy for both lighting and power was stated to be about 12 centimes per shell.

In the city of St. Etienne the prices charged for electric energy for lighting and power cannot exceed certain maximum rates which are stipulated in the franchise granted by the city to the electrical company that supplies electric current in that city. For lighting current the maximum rates decrease with the number of hours of use per year, as follows:

For the first 1,000 hours.....	55 centimes per kw.-hr.
For the next 400 hours.....	50 centimes per kw.-hr.
For the next 400 hours.....	45 centimes per kw.-hr.
For the next 1,500 hours.....	40 centimes per kw.-hr.
For all other.....	30 centimes per kw.-hr.

The number of hours of use per year is obtained by dividing the total number of kilowatt-hours consumed during the year by the total capacity of lamps installed, measured in kilowatts.

The franchise also gives the maximum figures allowable for "flat-rate" lighting current.

For power, there is a "flat-rate" scale of charges per horsepower per year, and there are also two methods of charge for "metered" current, as follows:

(a) A rate which is constant, independently of the total amount consumed per year, and which is fixed at a maximum of 30 centimes per kilowatt-hour.

(b) A rate which is not constant, but which decreases with the size of motor and the total yearly current consumption, and also requires a certain yearly minimum payment per kilowatt to be made by the consumer independently of the total current consumption indicated by the meter.

The latter method of charge (b) is that known as the "fixed-plus-variable charge" method. The variation of cost (in centimes per kilowatt-hour) with the size of motor and with the number of hours of use per year are shown in the table following:

Capacity Installed, kw.	Minimum Fixed Annual Charge Per Kw. Installed	Centimes Per Kilowatt-Hour for			
		First 1,000 hrs.	Next 1,500 hrs.	Next 2,000 hrs.	All Above 4,500 hrs.
0 to 2.....	240 frs.	30	30	25	20
2 to 4.....	200 frs.	25	25	20	15
4 to 6.....	160 frs.	20	20	15	10
6 to 10.....	155 frs.	19	15	9	5
10 to 15.....	150 frs.	18	12	8	5
15 to 24.....	150 frs.	17	11.5	7.5	5
24 to 36.....	150 frs.	16	11	7	5
36 to 50.....	150 frs.	15	10	6.5	5
50 and over.....	145 frs.	14	9.5	6	5

In St. Etienne and vicinity there is much weaving and like textile work done on looms and apparatus located in the workers' homes, and the small motors installed for these and similar purposes aggregates over 3000 hp. It is very important to have a finely graded sliding-scale for power current, like the above scale.

It will be seen, from the table, that the minimum price for metered power current comes down to as low as 5 centimes (approximately 1 cent) per kilowatt-hour, same as at Lyons. This is a very low figure, which will be a revelation to most users of electric power in American cities. This low cost would not be possible in cases where "black" coal is the principal source of energy, instead of "white" coal.

This low cost of power current shows the great benefits which have been derived in a large region of France from the development of hydroelectric power in the "white coal" region. They constitute the best possible argument in favor of further and even increased activity in the development of hydroelectric power wherever it is available in France.

For the purpose of comparison with power costs in a region where "black coal" is the only source of power, we may take the cost of electric power at Bordeaux. The power used for operating the coal and ore-handling and conveying system at the Bordeaux docks costs 12 centimes per kilowatt-hour. This is to be regarded as a low figure for electric power current derived from a steam station, even allowing for the advantage which a seaport city has of being able to get its coal supply at lower cost than an inland city. Nevertheless, this very reasonable cost is still 2.4 times greater than the lowest cost of electric power at Lyon and at St. Etienne. This is a significant fact.

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(A second article on electrochemistry and electrometallurgy in France will follow.)

Potassium Chlorate in Japan.—A very interesting phase in the manufacture of this product has developed since the starting of the war, in Japan. Previous to the war there was only one firm in Japan manufacturing this product. This was the Nihon Kagaku Kogyo Kabushik Kaisha, which produced 300 tons of chlorate per year. The consumption of potassium chlorate in Japan at that time was about 4000 tons per year and was imported from Germany and other European countries. Since then the number of manufacturing concerns has increased from one to at least eight, which have an annual output of over 3500 tons. At present this output exceeds the local demand and of late a considerable amount of potassium chlorate has been exported to China, Russia and the South Sea Islands. During the months of August and September the above mentioned eight firms exported a total amount of 534,268 pounds of chlorate. A peculiar phase of this industry is that the firms manufacturing this product must have the permission of the government before permitted to export.

A Bibliography of Alloys: Binary, Ternary and Quaternary Systems Whose Equilibria Have Been Investigated

By Clarence Estes

The study of alloys in a systematic way began in the latter part of the nineteenth century coincident with the introduction of the pyrometer and the microscopical examination of metals. The introduction of these instruments made it possible to go much deeper into the study of the equilibrium diagrams of alloys. Because of the many requirements for alloys with special properties, a complete systematic study of the equilibrium diagrams of alloys should include at least the following investigations of each member of the series: (1) thermal equilibrium, (2), thermal expansion, (3) thermal-electric force, (4) molecular volume, (5) density, (6) hardness, (7) tensile strength, (8) ductility, (9) electrical conductivity, (10) solution tension, (11) magnetic susceptibility, (12) separation and identification of compounds, (13) microscopical examination, (14)¹ x-ray examination, (15)² optical rotation of polarized light from polished surfaces, (16)³ photoelectric effect, and possibly others.

Various investigators have studied more or less completely practically all of the binary systems of the common metals and a great many of the rarer metals; also about sixty ternary systems, and several quaternary systems. Tammann⁴ has summed up in the form of a chart the various binary systems which have been investigated under his immediate supervision at the Göttinger Institut für Anorganische Chemie. Bornemann,⁵ Faust⁶ and others have given short summaries of the binary systems of alloys, but so far as the writer is aware there has not been published a paper listing all the binary, ternary and quaternary systems investigated, and including a bibliography of each system. It is owing to this fact that the writer has endeavored to show in a chart all the binary systems which have been published, and also to include a list of ternary and quaternary systems which have been abstracted and published in the Chemical Abstracts up to Jan. 1, 1917, and the more important investigations prior to the publication of the Chemical Abstracts.

The chart of the binary systems investigated is published on page 274 and is immediately followed by the list of references to each system investigated.

The list of references to ternary systems investigated begins on page 281, that of references to quaternary systems investigated on page 281.

In many cases it was very difficult to decide whether the data were sufficient to justify including a system in the chart or not. No doubt, in some cases, systems have been included which some readers may think should have been omitted, while, on the other hand, some systems may have been omitted which should have been included. However, the writer, if in doubt, has endeavored to include a system rather than omit it.

Accompanying the chart is a list of references for each system investigated. A number in a square on the chart indicates that that system has been investigated, and this number refers to a citation in the list of references. Letters under certain elements in the first row indicate that those elements have had their Allotropic modifications investigated, and these letters also refer to a citation in the list of references. The bibliography has been compiled mainly from the Chemical Abstracts, from Desch's Metallography, and from original articles.

¹Nature, 91, 607.

²Z. anorg. Chem., 83, 267; 88, 265.

³H. Stanley Allen Photo-Electricity, Longmans, Green & Co.

⁴Z. Elektrochem., 14, 789.

⁵Metallurgie, 6, 236, 236.

⁶Z. Elektrochem., 18, 430.

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1908, 1264 Metal Ind., 6, 45
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Synopsis of Recent Metallurgical and Chemical Literature

Coal and By-Products

The Action of Solvents on Coal.—Very little is known as to the exact chemical character of coal, one of the most important of our mineral resources. The *Journal* of the Society of Chemical Industry, Nov. 30, 1916, gives a résumé of work done along these lines. The early attempts to extract the soluble or resinoid constituents of coal by means of solvents, met with little success. Alcohol, ether, chloroform, benzene, and acetone were tried, but ordinary bituminous coals yielded only about 1 per cent or less to the solvent, although there are one or two exceptions to this. Under high pressure (55 atmospheres) and at elevated temperatures (275 deg. C.) higher extractions have lately been made by Fischer and Glud. Pyridine was found by several experimenters to give high extractions. With some gas coals Bedson found extractions with pyridine from 22.53 to 33.59 per cent. There is an approximation between the amount dissolved by pyridine and the percentage of volatile matter. Phenol and aniline have also been found to have considerable solvent action. From the researches of Burgess, Wheeler, Clark, and Jones, on pyridine and chloroform extractions it would seem probable that the constituents of the coal derived from gums and resins are the least stable ones, which yield paraffins on distillation, while the cellulosic degradation product is the more stable, hydrogen-yielding constituent. Little is known as to the actual identity of the constituents of coal. Several compounds have been isolated but they are present in such small proportions as to make them of theoretical interest only. The cellulosic portion consists of compounds of the furane type and compounds having structures similar to that of the carbon molecule are also present, but it is improbable that coal contains free elementary carbon. The resinic constituents are considered to consist of compounds in which alkyl, naphthene, and hydro-aromatic groupings are attached to more complex groupings. The oxygenated resinic derivatives are probably chiefly cyclic oxides, and esters, ketones, acids, etc., are almost completely absent. Free hydrocarbons are present in small quantities, but it is doubtful whether aromatic groupings exist.

Difficulties of the British Coal-Tar Color Industry in War Time.—The chief cause which is hindering the development of the coal-tar dye industry in England is the difficulty in obtaining adequate supplies of benzol, toluol, etc., owing to war demands. In a paper read before the Royal Society of Arts and abstracted in the *Iron and Coal Trades Review*, C. M. WHITTAKER gives some of the difficulties encountered in increasing the industry. In 1913 Great Britain imported £1,946,224 worth of coal-tar colors, representing 42,000,000 lb. of colors. It is estimated that Germany supplied

£1,800,000 of this and as the total invested capital in dyestuffs factories in England was not over £500,000 a serious problem was presented. Many of the intermediates were purchased from Germany and attention had to be turned to making these before increasing the production of finished dyes. Difficulty has been found in securing adequate chemists, in getting deliveries on apparatus and workmen to erect it and in obtaining supplies of raw materials. The Government controls the benzol and toluol supply for explosives manufacture and for use in making dyes for Government equipment. The balance is available for general dyes. Acids also—nitric and sulphuric—are vital to the dye industry and just as vital to the explosives industry, and as the supply is far short of the demand, another difficulty is encountered here.

Recovery of Benzol from Coal Gas.—At a meeting of the London Section of the Society of Chemical Industry, on Jan. 15, Dr. R. LESSING read a paper on "A New Method of Extracting Vaporous Constituents from Coal Gas." An abstract of the paper is given in the *Chemical Trade Journal and Chemical Engineer* of Jan. 20. Dr. Lessing stated that so far it had only been used for research purposes, but there were hopes that before long it would be made available on a commercial scale, so that it could be used on gas-works in the ordinary way both for the purpose of extracting benzol and as a check on gas manufacture generally. The principle of the process is that of a dry scrubber filled with solid absorbent material, which will strip the benzol from the gas without the employment of runnig wash oil, and from which the volatile products could be recovered by steam distillation. At first it seemed that crushed pitch would serve the purpose of the absorbent material, but it was found that its viscosity decreased to such an extent by the absorption of the solvents from the gas that it began to run after a while, and was liable to consolidate and block the passages of the apparatus. Finally a rigid material was decided upon, and broken firebrick was found to serve the purpose. The operation of the process is as follows: The gas is passed through a closed vessel which contains the porous material soaked in a volatile oil—for instance, green oil or gas oil. The inert material may consist of broken highly porous brick, or preferably of molded pieces of a definite shape, volume, weight, and available surface. The various compounds in the gas which the oil dissolves—i.e., hydrocarbons and organic sulphur compounds, which when isolated are liquid at ordinary temperatures—are absorbed. When the oil has taken up the required amount of the substance to be extracted, which will depend upon the quantity and surface of the absorbing agent, the velocity and volume of the gas, the temperature and the degree of its saturation, the actual solubility of the vapors, and the absorbing oil and the vapor pressure of the solution formed, the gas inlet and outlet valves are closed, the gas current being directed into a second vessel. Steam is then blown through the material carrying the vapors and the absorbed compounds with it to the water-cooled condenser, and finally to a receiver fitted with overflow pipes for water and crude benzol respectively. It has been found advisable to provide the "scrubber still" with a jacket to avoid the condensation of steam, particularly on the walls. It is, however, not necessary to raise the whole of the inert-carrying material to the temperature of distillation. When distillation is finished steam is shut off, and the vessel is cooled by passing water through the jacket, and the apparatus is then ready for the next scrubbing period. By employing three or more sets of scrubber stills they can

be worked in rotation, a definite schedule being arranged for the three periods of scrubbing, steaming, and cooling. As gas passes through at the rate of 5 cubic feet per hour, twenty hours only are required for a test of 100 cubic feet, whereas with the method mostly used of bubbling gas through a train of four wash bottles filled with oil a period of four days is required for a test of 100 cubic feet. In addition to this saving in time there is the extreme simplicity of the apparatus, which combines boiler, container, and superheater in one.

Iron and Steel

Construction of Hot-Blast Stoves.—At the New York meeting of the American Institute of Mining Engineers, in February, LINN BRADLEY, H. D. EGBERT and W. W. STONG, of the Research Corporation, New York, presented some suggestions for hot-blast stove construction, to be used in connection with hot-dry cleaning of the gases by electrical precipitation. The authors think it advisable to construct the stoves from the viewpoint of getting the maximum amount of heat energy in the products of combustion. The two necessary conditions are the preheating of the air added to the top gas, together with obtaining a better mixture of the air and top gas, and the lining of the stove with a brick that will withstand a high flame temperature, will conduct the heat energy along certain directions, insulate the flow of heat along other directions so as to make the flow of such energy more uniform. It is recommended that several kinds of brick be used: one type which is a good insulator of heat energy to be used for lining the stove and for making partitions through the stove to restrain the flow of heat; another type of brick or material with high refractory qualities; and a third type which will be a good conductor of heat energy.

The authors recommend that some experiments should be conducted and calculations made to determine the proper size, shape and composition of checker bricks, in the light of the points brought out in the paper. Through improvements in design and the use of a hot-dry method of cleaning the top gas, it may be possible materially to lower the installation and the operating costs of the stoves, and obtain results equal to those obtained in present practice. As for preheating the combustion air for the stoves, this is somewhat analogous to preheating the blast for the furnace, but it is unnecessary to employ as expensive a method. The combustion air could be preheated by the stove exist gases by means of suitably designed heat-exchanging apparatus placed above the stove, the preheated air being delivered to the stove burners by means of fan and duct. Calculations readily show the importance of adopting this suggestion and should be proven in practice. The hot-dry method of cleaning the top gas for burning in boilers is stated to be more efficient than the wet method for the following reasons: (1) the top gas is made cleaner than when the wet method of cleaning is used; (2) the sensible heat energy of the top gas is conserved; (3) the temperature of the gases in the boiler is increased, making possible the use of a gas of lower calorific value; (4) no slags or corrosion results from the dust settling on the furnace bricks or the boiler tubes. At the Riverside cement plant and in sulphuric acid plants the electrical method is now being used to clean gases at about 900 deg. Fahr. Several other gases have been cleaned at this temperature. A cheap and efficient method of cleaning gases at a high temperature will thus introduce a new epoch in the saving of the sensible heat energy that is now being wasted in so many instances.

Recent Metallurgical and Chemical Patents

Iron and Steel

Welding.—For welding a cutting edge of high-speed steel to a low-carbon steel shank, JOHN A. HOPE of Montreal, Canada, patents a welding composition which consists of 60 parts 80 per cent ferromanganese, 20 parts 50 per cent ferrosilicon and 20 parts burned borax (1,209,841, Dec. 26, 1916).

Uranium Steel.—Three patents of JOSEPH M. FLANNERY (assigned to Standard Chemical Company of Pittsburgh, Pa.) refer to the use of uranium in high-speed steel. The first patent (1,210,625) refers to the use of uranium as the sole added toughening agent and specifies a content of from 0.05 to 5 per cent of uranium in steel. In the second patent (1,210,626) it is stated that by incorporating 3 per cent of uranium into tungsten steel containing as low as 8 per cent tungsten, a high-speed steel is produced which has all the qualities of tungsten steel containing 18 per cent of tungsten. The third patent (1,210,627) refers to the analogous addition of from 0.4 to 3 per cent of uranium to molybdenum steel containing from 3 to 10 per cent of molybdenum (1,201,625, 1,201,626, 1,210,627, Jan. 2, 1917).

Tungsten

Method of Producing Malleable Tungsten.—According to a patent of ARMIN HELFGOTT of Uj-Pest, Austria-Hungary, assigned to the General Electric Company of New York, better results can be obtained in making malleable tungsten if a mixture of granular tungsten and finely powdered tungsten is used as the starting material than when either of these is used singly. When the mixture is used the finely powdered metal acts as a binder upon sintering, cementing together the grains of granular tungsten. The common method of making malleable tungsten is to press dry tungsten powder into suitable forms and then sinter. It is advisable to have the tungsten powder free from oxide, and since the fine black powder always contains oxide its use alone is open to this disadvantage. When granular material only is used the adhesion is very slight between the particles. The method of using a mixture of fine and granular aims to overcome these difficulties as far as possible. The patent states that the fine powder may be freed from oxide by heating in a current of hydrogen (1,206,704, Nov. 28, 1916).

Plating

Nickel Plating.—A patent of CLARK W. PARKER, assigned to the Parker Rust Proof Company of America of Detroit, Mich., refers to a quick nickelplating process. The steel surfaces to be plated are first finished and then treated with a weak solution of phosphoric acid (prepared by placing 3 lb. of manganese dioxide in a solution of $\frac{1}{2}$ gal. of phosphoric acid in 100 gal. of water and heating to the boiling point). They are then cleaned and smoothed with a metal brush or brushed with emery or pumice, and are then immediately plated with nickel in a nickel sulphate solution. "For some reason not now understood a much higher voltage may be used in nickelplating articles thus treated than is permissible with ordinary practice, as the burning of the edges of the articles being plated, which is common with high voltage under ordinary conditions, is entirely lacking. The time required to deposit a given coat is greatly reduced (1,211,218, Jan. 2, 1917).

Smelting

Smoke Condenser.—A patent was granted to FRIEDRICH W. BREITENSTEIN of Vancouver, Canada, for the condensation and recovery of sulphur and arsenic from

smelter smoke. The invention comprises a smoke flue leading from the smelter composed of a series of connected sections, each having an intake lead and a discharge lead at an angle to the intake lead at a point to the rear of the front end of said intake lead, and means at the front end of each intake lead to project the flame into the said intake lead and toward the end of the flue. The construction of the flue is given in a series of drawings (1,188,240, June 20, 1916).

Dust Collector for Blast Furnace.—Fig. 1 and Fig. 2 show the dust-collecting device for blast furnaces patented by PASQUALE DE SIMONEY of Youngstown, Ohio. Fig. 1 shows the device attached to the upper part of a

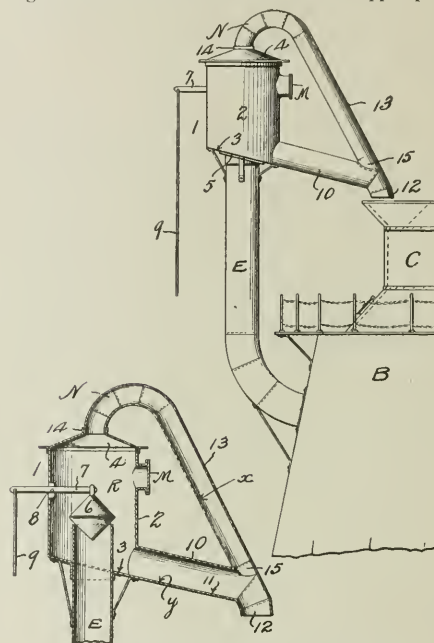


FIG. 1 AND FIG. 2.—SMOKE CONDENSER

blast furnace. The underlying principle of the device is the dropping of the solid material, due to the decrease in velocity of the gases coming from the furnace as they enter the expanded chamber 2. This chamber has an inclined floor 3 and an upper cap 4. The explosion pipe *E*, as is seen in Fig. 1, enters partway into the chamber 2. The inlet of the explosion pipe is provided with a cone valve 6. The valve is operated by lever 7-8-9; 10 is a gravity return pipe and returns the solid material into the furnace. Pipe 13 is intended to carry the finer materials back to the furnace more rapidly than if the coarse and fine materials were mixed. This pipe has a greater incline than pipe 10, thus facilitating the removal of the fine material. As an explosion takes place in pipe *E*, the valve is lifted, the fine material is shot up into the neck *N* of pipe 13 and goes to the furnace, while the heavier particles drop to floor 3 and pass through the pipe 10 (1,192,395, July 25, 1916).

Acid Resisting Strainer for Smelters.—Figs. 3 and 4 show the construction of a bag for filtering fume patented by DONALD M. CAMERON of Lowell, Mass. It consists of a cylindrical, seamless, tubular body having its upper end closed. The material of this bag consists of yarns of camel's hair woven into the desired form. The strainer is adapted to be suspended in the flue of a

smelter, the fumes and smoke passing through it. The solid particles are withheld in the bag while the filtered smoke or fume passes to the stock. The solid materials adhering to the wall of the bag may be removed at any

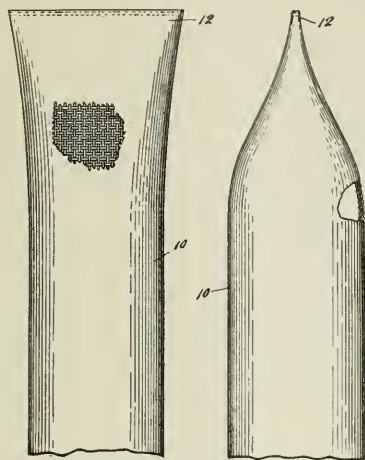


FIG. 3 AND FIG. 4—BAG FILTER

time by shaking the bag. The claim of the patent demands that the material of which the bag is made be acidproof and made up of fibers, the striations of which are longitudinal and free of scale like formations (1,190,512, July 11, 1916).

Electric Furnaces

Electric Ore Reduction Furnace.—An electric reduction furnace which embodies improvements on previous patents on the same furnace is described in a patent of JAMES W. MOFFAT of Toronto, Canada. The furnace comprises a feeding chamber for ore and flux, a reducing chamber or stack, and a crucible in which are six electrodes. The stack and crucible are a unit and can be tilted independently of the feeding hopper. When back in position after tilting, the openings in the top of the stack for exit gases and feeding are flush with the openings in the plate above, which holds the feeder and exit gas pipes. At the bottom of the stack and just above the crucible is a pipe for introducing reducing gas. In the first patent (950,595, March 1, 1910) trouble was experienced with the tapping, and these troubles were overcome in a later patent (1,108,924, Sept. 1, 1914). In this furnace the reducing chamber was disconnected from the crucible in tilting. In the present patent the crucible and reducing chamber tilt together as a unit and the loss in dusting is minimized by having the exit gas openings away from the feeding opening (1,208,817, Dec. 19, 1916).

Electric Furnace.—Two patents were granted to JOSEPH LAWTON DIXON of Detroit, Mich., for improvements on electric furnaces. The improvements relate especially to that type of electric smelting furnaces where the current may be made to pass either from one electrode to another over the bath or from one or more of these either wholly or in part through the bath and the furnace lining. Furthermore, it is the object of these patents to control the phase relations of the current coming from specially devised transformers by means of switches, so as to cause different proportions of the total current to flow through the bath and the lining. This is to be accomplished with either two or three-phase current systems in such a manner as not

to unbalance the load on the main lead. Fig. 5 shows one of the possible connections as given in the patents, and needs no further comment. The phase relations of

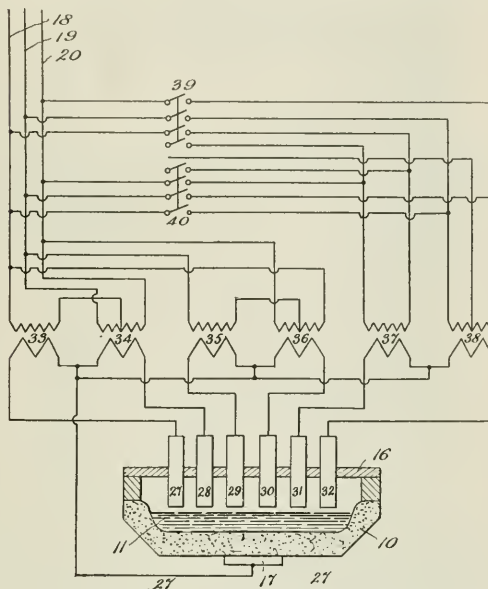


FIG. 5—DIAGRAM FOR ELECTRIC FURNACE CONNECTIONS

the currents are specially illustrated by the patentee (1,197,458 and 1,197,459, Sept. 5, 1916).

Various Processes

Process for Volatilizing Metals.—Fig. 6 illustrates an apparatus used for the volatilization of metals patented by SELDEN IRWIN CLAWSON of Salt Lake City, Utah. 7 is the roasting part of the apparatus, where the ore is roasted in the presence of air, which is supplied through 10, the same opening serving for the rabbling. Through 12 the roasted product drops into the muffle 3, which is made airtight by means of the door 4. Halogen compounds are added through 13, which is provided with a worm gear. The volatile halogen compounds issue from the muffle through 5, which leads to the fume arrester. The process consists generally in the roasting of an ore containing gold, silver, copper, lead antimony, cobalt, zinc and other metals whose halogen compounds volatilize in the presence of air and with the addition of sulphur if necessary. The sulphur is added during the roasting so as to form sulphates. The object in the roasting operation is to convert all the metals into sulphates with the exception of the iron, which should as far as possible be roasted to oxide. After converting the metals into the sulphates, halogen salt is added to the roasted product. In this state the mixture is heated in the muffle, chlorides being formed, which volatilize and are collected (1,192,037, July 25, 1916).

Method of Making Wall Coverings.—A method of making wall coverings which makes use of electrotyping is patented by JAMES W. MCINDOE of Medford, Mass., and ARTHUR E. WHITNEY of Winchester, Mass. If it is desired to transfer the configuration of a wood veneer to a sheet of wall board or onto paper, two pieces of wood veneer of similar design are taken. The ends are abutted together with the backs secured to a flat plant and the design joined continuously at the junction of

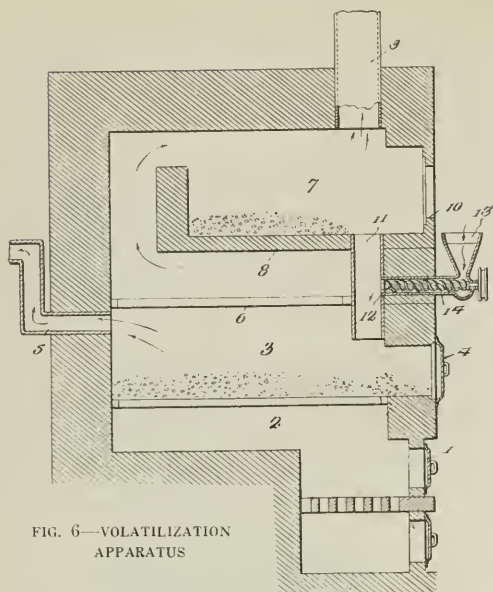


FIG. 6—VOLATILIZATION
APPARATUS

the two pieces of veneer. The gum is then removed from the grain by turpentine, and the surface is spread with carbon and an electroplate formed. The electroplate is then trimmed and shaped into a cylinder with its printing face outward, and is provided with a solid backing of copper and soft metal. The cylinder is then ready for printing (1,208,808, Dec. 19, 1916).

Production of Sugar from Sugar-Beets.—A process of producing sugar from the sugar beet and its by-products is patented by GEORGE H. BENJAMIN of New York. The object of the patent is to make it possible to so treat the beets that they can be kept for long periods before making sugar from them, thus doing away with the disadvantages of the usual working season of only three to four months. The object is accomplished by first slicing the beets and then treating them in a dehydrator with dry air. As a result of the dehydration of beets the water is greatly reduced and the available sugar content increased as shown by the following analysis:

	Fresh cosettes	Dehydrated cosettes
	Per cent	Per cent
Water	78.98	10.67
Polarization	14.80	65.10
Polarization on dry substances..	70.41	72.87
Invert-sugar.....	None	None

Many advantages are claimed for this dried product on account of the greater concentration of sugar and because the dried beets can be stored for a long time if kept dry (1,207,840, Dec. 12, 1916).

Manufacture of Waterproof Cloth.—A process of waterproofing cloths is the subject of a patent of ALFRED O. TATE of Montreal, Canada (assigned to the Tate Electrolytic Waterproofing Company, Inc., of New York). In this process the cloth or fabric to be treated is passed between two rolls which serve as electrodes, after first being treated with a saponaceous solution, preferably of common castile soap. The positive electrode or roll should be of the metal the hydroxide of which it is desired to incorporate in the fabric; in this case aluminium. The negative electrode may be of any

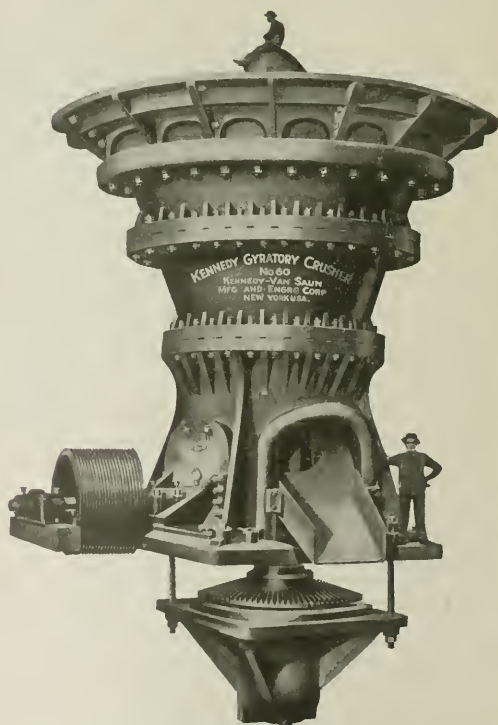
suitable material, such as graphite. While the material is passing between the electrodes, a saturated solution of aluminium sulphate is applied to the fabric by spraying or other means. At the same time the hydroxide is precipitated on the fabric from the anode and aluminium palmate is formed from the aluminium salts and the sodium palmate of the soap solution. After passing between the rolls the fabric is washed and dried (1,208,400, Dec. 12, 1916).

A Mammoth Gyratory Crusher

What is stated to be the largest crusher in the world has recently been installed at the Michigan Limestone & Chemical Company's plant, at Calcite, Mich., by the Kennedy-Van Saun Mfg. & Eng. Corporation, 120 Broadway, New York.

The Michigan Limestone & Chemical Company is operating a property in Northern Michigan on the shores of Lake Huron, at Calcite, which is within a few miles of Rogers City. It comprises approximately twelve thousand acres of limestone land. The quarry face at the present time is about 1½ miles in length and has an average face height of about 50 ft. A large number of churn drills are used for drilling the full height of the face, which is shot off in successive layers with dynamite.

Six 110-ton steam shovels with 3½-yd. capacity dipper are used in shoveling the blasted material into trains of eight to ten cars of ten (10) yards capacity each. These are hauled by steam locomotives on standard gage tracks. The trains are controlled by a tower man with an electric signal system so that the engine man of each train is shown which shovel he is to serve on each trip, and the delivery of the stone laden trains



THE WORLD'S LARGEST CRUSHER

is therefore systematically controlled for feeding the primary crusher.

As the tracks approach the crusher house they are arranged so that the stone can be delivered either side of the crushers. Up to the present time all of the stone has been delivered to a No. 42 Kennedy gyratory crusher, which has been in service about five years, and it has produced an average of about 16,000 tons of crushed limestone per 20 hr. day. The re-crushing operation to produce the finer sizes of stone required is accomplished with a No. 7 $\frac{1}{2}$ Kennedy gyratory crusher.

Recently this company has installed an additional primary crusher in order to secure a large tonnage capacity, and also to receive larger stones so that the cost of quarry blasting would be minimized, and there will be less opportunity for any delay from pieces not entering the crusher on account of the receiving opening being of insufficient size.

This No. 60 crusher, which is the largest ever built anywhere in the world, commands attention, and some of its features should be of interest. It has a capacity of approximately 25,000 tons per 20-hr. day crushing limestone from a maximum size, which will enter its receiving opening, having a combined area of 60 $\frac{1}{2}$ " by about 35 ft. down to about 8" and finer.

The crushing space between the head and concaves holds 30 tons of stone and this, together with the hopper, which flares out above the head and concaves with an outside diameter of about 22 ft., affords receiving capacity of over 65 tons of stone.

The design of this unusual machine naturally involved much careful study, not only as regards to its operating features but also its manufacture and transportation. For instance, its spider, which is made in a single casting, came within one inch of the height limit permitted by railroad regulations, even when shipped in a well bottom car.

The top shell on account of its great weight could not be shipped in one piece, and was therefore constructed in two horizontal sections, connected by heavily flanged male and female tapered machined joints, securely bolted, so that its strength is increased instead of reduced by this procedure.

The main shaft is about 3 ft. diameter at its largest portion and about 28 ft. long. The total height of the machine is 34 ft. It is driven with 1 $\frac{1}{4}$ -in. Manila ropes by a 66-in. cast steel sheave, having 18 machined rope grooves. It is operated by the English system, so if as many as half of the ropes should fail from wear the crusher can still serve, continuity of operation being of greatest importance. The source of power is a 300-hp. motor, which has been found ample for the requirements.

In the design of the various parts of this machine, the calculations were based on known factors, derived from experience with a large number of similar crushers from the smallest size up to the largest heretofore built. While the detailed processes of these calculations would manifestly involve too much space for a description of this kind, it is interesting to note that the parts of this No. 60 crusher have to withstand stresses produced by a pressure of more than 2,000,000 lb. at the crushing surfaces. The hydraulically forged steel main shaft is designed on the basis of a maximum fiber stress of 10,000 lb. per square inch, semi-steel casting of 3500 lb. per square inch and steel casting 8000 lb. per square inch.

The eccentric is of the patented spherical ball and socket type, so that this most important bearing is self-aligning. This largely explains the low power consump-

tion. This steel eccentric bearing is lined with a phosphor bronze bushing constructed in halves, thus forming the most perfect bearing construction known, and which removes the annoyance of rebarbiting, as in the case of rigid eccentric crushers. Moreover, as the proper eccentricity is maintained the reduction of capacity is avoided. The bearing pressure between the shaft and the bronze lined eccentric bearing is designed not to exceed a maximum of 175 lb. per square inch.

The broken stone from this crusher is spouted to a belt conveyor which carries it on an upward incline to revolving screens, the rejections from which are fed to smaller crushers producing the finer sizes of stone required. It is then either conveyed to ground storage or to bins from which it is loaded by shuttle conveyors on to specially built steam boats for transport on the Lakes to customers, principally large steel producers who utilize this limestone for furnace flux.

A Remote Liquid Level Gage

A gage for showing the level of liquid in a tank at a point at a distance from this tank has been developed by the Universal Tank Gage Company, of Tacoma, Washington. A diagram of the gage and connections is shown in Fig. 1. The gage consists of a U tube containing a colored liquid. One arm of the tube is open to the air; the other is cut quite short and connected to a small reservoir of a size sufficient to hold the contents of the other arm. The top of the reservoir is connected by means of $\frac{1}{4}$ -in. copper tubing to the tank; this tubing terminating in a small bell on the bottom of the tank which is placed open and downward. At the gage end of the connecting tube is a small hand air pump and valve, as shown in the illustration.

After the instrument is set up and connected to the tank, air is pumped into the tubing until it hubbles freely from the bell in tank. The air then in the tubing is under atmospheric pressure plus the head due to the height of the liquid in the tank, which is exactly counterbalanced by the column in the U-tube. As the contents of the tank is drawn off the air escapes from the bell and the column in the gage glass falls. When the tank is filled the process is reversed, but if air is

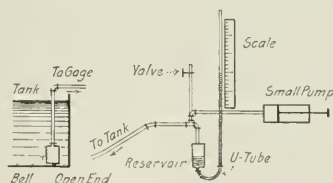


FIG. 1.—DIAGRAM OF LEVEL GAGE CONNECTIONS

compressed too much and the liquid is forced into the copper tubing a few strokes of the hand pump will correct it.

The change in temperature is automatically cared for, a rising temperature merely forcing a little air out of the bell in the tank. A falling temperature will cause the column of liquid to read slightly lower than it should and this can be corrected by using the pump. There is no capillary action to be adjusted for, it is claimed, since there is no liquid in the small tube.

This gage is guaranteed to read within 1/16 in., and its operation is independent of the location of the tank. It is made in various forms for use on fuel oil, water, gasoline or any tank containing liquid.

Recent Developments in Operating Sugar Mills

One of the most important strides of progress in the cane-sugar industry has been the installation of the electric drive in all departments of the factory or "Central"—the name in use in all Spanish countries.

The principal heavy machinery in a cane-sugar factory are the 3-roll mills and 2-roll crushers which extract the juice from the cane. Similarly to the rolls in steel-rolling mills, each cane mill is generally connected through double-reduction gearing to its individual steam engine, while other apparatus in the plant, such as centrifugals, conveyors, etc., are arranged in groups and belt-driven by separate engines. All pumps and the boiler-room auxiliaries are usually direct-acting steam units.

The first cane-sugar mill to be completely electrified was Central Amistad, located in Guines, Cuba. The electrical system was designed and installed by the Kelvin Engineering Co., Inc., of New York. The power plant contains three 1000-kw., 3-phase, 60-cycle, 480-volt turbo generators, and all mills, conveyors, pumps and auxiliaries are driven by direct-connected 3-phase motors.

The complete electrification of Central Amistad was finished in 1913, the plant at that time consisting of six 3-roll mills and one 2-roll cane crusher, capable of grinding 2200 tons of cane per 24 hours. The progress made in the electrification of sugar mills since that date is shown by the fact that up to the present time over 30 mills have adopted the system.

The advantages of the electric drive in sugar mills are similar to those obtained in other industries, especially those where the exhaust steam is used for heating, drying, evaporating or other industrial purposes. The most desirable operating condition to be obtained in a cane-sugar mill is high extraction of the sucrose or sugar in the cane with minimum fuel consumption, which in sugar factories means without the purchase of additional fuel. The fuel always used in a modern factory is the bagasse or fiber of the cane after it has been crushed and the sugar juice extracted. Whether the mill units are steam or electrically driven, high extraction can be obtained provided a sufficient quantity of maceration water, *i.e.*, water added to the crushed cane to dissolve the sugar, is used and a sufficient amount of fuel is available or purchased to evaporate this water added to the cane, but in order to secure high extraction at a minimum fuel consumption and operating expense, the mill must be electrically driven.

For example, in the majority of steam-driven sugar mills, a large amount of steam is required to furnish power to the roll and crusher-mill engines, pumps and auxiliaries. The exhaust from these greatly exceeds the amount required in a modern efficient sugar evaporating system. However, as the evaporating systems of many of the mills are very uneconomical, consuming all of the exhaust steam available from the several engines, and not infrequently additional live steam, the inefficiency of the combined equipment is not readily noticeable. To have an efficient evaporating system without a corresponding power system, or vice versa, would, of course, not be productive of economical results. In the first place, the power equipment produces more steam than can be used in the evaporators, multiple effects, etc., and in the second place this apparatus requires more steam than can be supplied by the power equipment.

As it is possible to design modern evaporating and heating systems so as to require only such quantities

of exhaust steam which may be available the first problem of economical steam consumption is solved by the installation of the steam-turbine-driven electric power plant and the electric-motor drive, and then designing the heating and evaporating system to require only the available exhaust steam. This combined equipment gives maximum extraction without the purchase of fuel. In fact, the bagasse produced by an electrified mill is always in excess of that required for fuel.

Other advantages claimed for the electrification of sugar mills besides the economy in fuel are greater ease of installation and lower first cost. In operation it is possible to vary the speed of electrically motor-driven rolls relative to the others and independently of them in accordance with the percentage of fiber in the cane and the quantity of maceration water. It is possible to stop or start, or handle in any desired way, any one of the various mills without affecting the operation of the others. Should a mill break down or otherwise become disabled, it does not affect the remainder of the plant. There is also less danger of breakage, as neither the inertia of the moving parts nor the power of the motor, which is only of sufficient size for one mill, will be enough to cause breakage should a sudden resistance, such as a piece of scrap iron or railroad iron, be accidentally encountered in the roll. Further, each motor circuit is protected by modern safety devices and overload cut-outs. The motors require no attention whatever, and the occasional starting and stopping can be attended to by a few men. If the controlling apparatus is installed on a convenient platform, according to the modern idea of centralized control, but one man is needed for the complete control of all the grinding mills.

Personal

Dr. Herbert H. Dow lectured before the Detroit Section of the American Chemical Society on Feb. 15. His subject was "The Evolution of the American Manufacturing Industries and their probable Trend in the Future."

Mr. Francis B. Dutton, superintendent of the Lebanon, Pa., furnaces of the Bethlehem Steel Co., has resigned to become superintendent of the Wharton Steel Co.'s plant at Wharton, N. J.

Dr. G. W. Gray, formerly connected with The Texas Company as chairman of the manufacturing committee, left their employ on Jan. 1 to become manager of The Midland Refining Company at El Dorado, Kan. At this point it is expected to build an oil refinery for the refining of the Mid Continent crude.

Mr. B. E. V. Luty of Pittsburgh, Pa., has just celebrated his twenty-fifth anniversary in iron trade journalism. He started on the old American Manufacturer and Iron World of Pittsburgh (Joseph D. Weeks, editor) on Washington's Birthday, 1892, and has been at the job one way or another ever since. For many years he has been the trusted and faithful special contributor to many technical and trade journals in this country and abroad. In his special field Mr. Luty stands alone, and the many friends which his loyalty to the iron and steel industry in the past twenty-five years has won for him are wishing him an equally successful and useful career for the next quarter of a century.

Mr. Russell B. Marchant, formerly treasurer of the J. G. White & Company, Inc.; Mr. Douglas I. McKay, formerly assistant to the president of J. G. White & Company, Inc., and Mr. Sanger B. Steel, formerly manager of Paine, Webber & Company, Chicago, have

been appointed vice-presidents of J. G. White & Company, of New York.

Mr. G. R. Petterson, who has been connected with the New York office of the Barrett Co., has been appointed assistant superintendent of the Chicago plant of the company.

Mr. Victor H. Werner, formerly connected with the engineering department of the Chile Exploration Co., has become associated with Paul O. Abbe of New York City.

Mr. Carolus S. Woodwell has left the employ of the Aetna Chemical Co. at Carnegie, Pa., where he held the position of supervising chemist to accept a position as research chemist with the Benzol Products Co. at Marcus Hook, Pa.

Mr. B. G. Worth, for over fifteen years associated with Mr. Walter Kidde as electrical engineer, has in the recent incorporation of this business been elected vice-president of Walter Kidde & Co., Inc., New York City. Mr. Worth's attention was in the past devoted mainly to power plant construction and factory electrification, and recently chemical engineering, building, etc.

Obituary

Edward Dyer Peters, the well-known professor of metallurgy at Harvard University and the Massachusetts Institute of Technology, passed away at his home in Dorchester, Mass., on Saturday, Feb. 17. He was born in Dorchester, Mass., in 1849, and graduated at the School of Mines in Freiberg in 1869, and also received a degree from Harvard in 1877. He became a lecturer at Harvard in 1903 and has been a professor of metallurgy there since 1904. He was well known to metallurgists both through his teaching activities, his books on copper smelting and other writings, and was an authority on the smelting of copper.

CURRENT MARKET REPORTS

The Iron and Steel Market

The markets have made considerable progress in recovering their tone since the quieting down that occurred in the fore part of February as a result of Germany's announcement of unrestricted submarine warfare. While there has been no great increase in the turnover there is decidedly more inquiry for steel products for third quarter and second half.

Buyers have become disposed to accept the view expressed by sellers, that the entrance of the United States into the war would result in greater demand for iron and steel and a tendency toward higher prices. According to the common appraisement, the chances that existed in January of iron and steel prices being lower at the close of the year have been greatly reduced by the new international developments. Possibly the common view in January was that there were even chances of prices being higher or lower by the end of the year. Now the chances seem to be distinctly in favor of higher prices.

While the steel market as a whole did not advance during February, an advancing trend was distinctly evinced. Under the lead of some of the independent pipe mills, a general advance occurred in iron and steel pipe, two points or approximately \$4 a ton in standard wrought iron and steel pipe and line pipe, and advances averaging \$4 to \$4.50 in oil country goods. The Carnegie Steel Company, which had been quoting 3.50c. on steel hoops, for delivery at mill convenience, withdrew from

the market, leaving the situation in the hands of mills quoting 4c. to 4.50c., according to delivery. A quotation of 4.50c. basis on black sheets was being made occasionally, but when the American Sheet & Tin Plate Company withdrew absolutely as a seller the sheet market became 4.75c. as minimum, prompt deliveries of small lots continuing to command 5c. to 5.25c. In no steel product has the slightest indication of weakness appeared, and thus while the market as a whole has not been advancing there has been a distinct upward trend.

EXPORTS

Exports of such iron and steel products as are reported by weight amounted in 1916 to 6,110,790 gross tons, December exports having been 580,961 tons. Exports of unfinished steel comprised an unusual proportion of the 1916 total, 1,508,727 tons of ingots, blooms, billets, slabs and sheet bars and 158,727 tons of wire rods. Wire rods have always been classed as "unfinished steel" in the domestic trade, but the rods exported are probably to be regarded as a finished product, being used largely for the manufacture of submarine nets.

Early in February fears were entertained that American iron and steel exports would be greatly curtailed by reason of the new German submarine policy, but the prospect is otherwise now. While many American vessels failed to sail, the entente allies need as much material as formerly and commandeer such shipping facilities as are needed, while the losses in the submarine areas have been less than was expected. Iron and steel exports to neutral countries are likely to be small for the remainder of the war, but they have been far from large thus far. There has been no diminution in inquiry for export material.

TRANSPORTATION

Transportation conditions grew steadily worse until Sunday, February 18, when, aided by moderate weather, all the railroads had an excellent movement and shippers had larger supplies of empties on Monday than for many weeks. The preceding week Connellsville coke shipments had been no more than about half the requirements, and additional furnaces tributary to Connellsville coke were forced to bank. At one time the production of pig iron at furnaces tributary to Connellsville coke, about three-eighths the total capacity of the country, was restricted by at least one-third, but with the loosening up in transportation conditions that has been more or less continuous since February 18, deliveries have been better, the volume of coke en route decreasing and there is every reason to believe the worst stage of the railroad blockade has been passed. The return to normal will be slow at best and it is doubtful whether the railroads will be able to furnish full facilities as long as the present industrial activity lasts. Thus far there has been a loss of something like a million tons in pig iron production, through transportation facilities being inadequate. The loss in steel production has been materially less, as most steel mills have had some reserves of scrap and pig iron upon which to draw.

Apart from the actual curtailment that has occurred in production, a great deal of inconvenience has been caused by car shortages and embargoes. Mills have been forced to revise rolling schedules, to suit the material available, or to fill orders that could be shipped. At most of the mills there are now large accumulations of finished product awaiting shipment. Some of it is at the bottom of piles and the orders will have to be rolled again. Even sheet mills, which are always provided with fair sized warehouses, have in several instances reached the limit of their storage capacity and have had

to curtail production to conform to the car supplies available.

PIG IRON

Never before in the history of the pig iron market has there been such a tangle. The usual equalization between producing districts has been impossible, on account of pig iron moving so slowly, or being blocked entirely. Ordinarily each district has its own tributary consumptive field and when a market grows weak it merely sells a larger tonnage in the twilight zone between it and the next district, but such equalizations have been impossible, when prompt deliveries only have been in request and prompt deliveries could be effected only with short hauls. Thus, for instance, the Philadelphia market is quotable at \$31.75 to \$32.75, including a freight of about 75 cents, while Buffalo iron is quotable at \$35 at furnace, when ordinarily Buffalo and eastern Pennsylvania iron compete together in New England territory. While the valley furnaces normally ship iron to points not very far from Chicago, valley foundry iron has been bringing \$35 to \$38 at furnace, while the Chicago district quotes \$32 at furnace and as far as concerns the freight rate could ship pig iron right to the valleys. Southern iron is below the parity with Chicago iron and still farther below a parity with valley iron, the Birmingham market being \$25 for prompt shipment and \$24 for second half, with a freight of \$4 to Chicago and \$4.55 to Pittsburgh, while valley iron at \$35 to \$38 has been sold to Pittsburgh consumers with a freight of 95 cents. The Alabama furnaces can ship iron, but the market is not concerned with prompt shipment. It is a matter of prompt delivery.

While valley foundry iron has been bringing \$35 to \$38, valley basic iron remains at \$30, although the cost of production is substantially the same. In this case the divergence is not that there is an abnormally heavy consumptive demand for foundry iron, it is rather that the steel mills were more forehanded in contracting for basic iron while, on the other hand, the furnaces long ago concluded there would be more demand for basic iron than for foundry and planned their production accordingly, thus forestalling the condition they intended to anticipate.

Non-Ferrous Metal Market

Friday, Feb. 23.—The freight congestion has had considerable effect on the lead market and has forced prices for prompt shipment to a very high level. It has had practically no effect on the spelter market, but has affected copper to some extent. Tin has declined considerably, owing to a good volume of arrivals. Antimony declined about the middle of the month, but recently has become firmer and advanced again.

Copper.—During the greater part of the past fortnight the copper market has been quiet. On Feb. 13 prompt electrolytic was offered at 35 cents and prompt lake at 34 cents. Despite freer offerings around the 15th there has been a slight advance and 37 cents is now asked for electrolytic and 35.50 for lake. Exports so far reported are 22,191 tons. It will be interesting to see what effect an improvement in the freight situation will have on copper.

Tin.—There has been a steady decline in tin since the high of 56 cents following the severance of diplomatic relations with Germany. This has been due to the good volume of arrivals, totaling over 3000 tons so far, and the 3000 tons afloat. The shipping scare has somewhat worn off. On the 21st it is understood that advices were received stating that shipments from the East Indies would be curtailed. From 53.25 on Feb. 13 tin declined steadily to 48.75 on the 20th, and then strengthened to 40 on the 21st.

Lead.—The Trust price of lead was raised to 8.50 on

the 9th. The lead situation has become increasingly serious and the freight embargoes have caused a great shortage. Independents' asking prices have risen until 10 $\frac{3}{4}$ cents have been paid for prompt lead, with early deliveries hard to get. The situation eased a little on the 21st.

Spelter.—In spite of the freight congestion spelter has advanced but a small fraction of a cent. Consumers are evidently well stocked. The market has been quiet, with producers showing little desire to push sales of futures on account of the high ore prices.

Other Metals.—Antimony has had a rocky career, declining to 29 on the 15th and then strengthening and advancing to 34 on the 20th, where it remains unchanged. The antimony market is very sensitive, owing to the uncertainty in the shipping situation, and the good demand. Aluminium is unchanged at 57 to 59 cents, magnesium can be had at \$3 to \$3.50, nickel is unchanged at 50 cents for electrolytic. Cadmium is \$1.50, quicksilver \$135, platinum (pure) \$105 per ounce, cobalt \$1.50 and silver 77 $\frac{1}{2}$ %. Silver was up to 79 on the 13th.

Chemical Market

The two factors that have been given the closest attention and that have played the most important rôles in the general chemical situation during the fortnight are the embargo that has been declared by railroads throughout the country on all freight except food-stuffs destined to this territory, and the unprecedented ocean shipping situation caused by the German submarine policy inaugurated on the first of this month. The former condition has resulted in a tighter situation in all chemicals ordinarily shipped to this center for distribution along the Atlantic seaboard, New England and other Eastern points. On the other hand, those goods, large consignments of which had been delivered here for export and are awaiting freight room, have felt the stress of delay. There is a consequent falling off in activity in those articles usually subject to good foreign demand.

Several price changes have occurred in the coal tar crudes, and these have affected to some extent the values of the many of the intermediates. The prices of benzol, toluol and naphthaline have stiffened, and phenol, which has been subject to considerable hammering in a downward direction, has taken an upward turn.

Benzol, although being produced now on a larger scale than ever before in this country, has been subject to a much wider demand for the use of explosives and for use in the manufacture of a more varied list of intermediates. The supplies available for immediate delivery and near futures have dwindled, and considerable difficulty is experienced in securing important quantities for consumption by users who are not under contract with manufacturers. The anticipation of government business has also played a part in stiffening the attitude of leading makers. The contract situation is less pressing, and no great movement is noted; manufacturers are not looking for contract business, and those consumers who are not covered for future requirements evince a desire to hold off, awaiting future developments.

Toluol has been subject to quite some buying for ultimate use of the government and important manufacturers are holding their product with considerable firmness. A few rather important contracts have lately been closed, and the majority of these have been placed at levels that show the firmness of the situation.

Naphthaline business is progressing on an enormous scale, and large producers are not showing any desire to take on business for contract, except with regular

users. Quantities held in second hands are being let out, however, and this is making the situation less tense, although these resale lots are commanding prices that average well up with the figures quoted by manufacturers. The English goods, owing to the high original cost, and the import duty of approximately 4c., are not being imported now to any extent.

Although phenol had been sold down to comparatively low levels, and more than one important manufacturer was offering goods at prices that were considerably below the ideas of other producers, the situation has changed. One of these makers was selling against a repudiated contract, and the goods have been almost entirely absorbed. The situation is now firmer, and some heavy purchases have been made in the last two weeks.

Aniline oil, aniline salts, dinitro phenol, dinitro chlor benzol, phthalic acid, monochlor benzol, diphenylamine, acetic anhydride have all been subject to heavy buying, and prices for the most part have increased.

Commercial alpha naphthol is now being made by a firm in the Middle West, and offerings are made for immediate delivery on contract. Ortho and para nitro toluol are also being made commercially on a larger scale, and moderately heavy demand obtains.

Owing to the entrance of a new manufacturer of alpha naphthylamine into the market, prices for this product are quoted in some directions at lower levels, although the pioneer maker has not changed his idea of price.

Among the heavy chemicals *bichromate of soda* has perhaps been given the most attention. Following a long siege of weak selling, attended by more or less steady declines, considerable demand set in from consumers at the low prices, and the market has in consequence taken an upward turn. Many speculative operators had been selling short, and these are now still buying to cover. A few at least have lost considerable money especially during the last week. This may be only a temporary state of activity, as many of the large users are under contract, and two of the most important consumers of this product are now making their own supplies. One manufacturer on the Pacific coast is now making an unusually good product, partly for its own consumption, and partly for the open market.

Hydrosulphite of soda has caused considerable attention lately, and one of the large textile mills is preparing to manufacture the product for its own use. Other users are showing interest and a wider demand is anticipated which will, of course, permit of an outlet for surplus quantities of the sulphur dioxide.

During the last few days *caustic soda* has been subject to unusually heavy demand, and prices have advanced both for spot, near future and contract. The sinking of a ship bound for Marseilles carrying an important consignment and the export demand for shipment to the Orient have been factors in creating a firmer market. Manufacturers are and have been limiting their contract deliveries and a large percentage of the weak lots offered by second hands have been taken out of the market.

Bleaching powder, on the other hand, has remained in a listless condition, and goods packed in large domestic drums, as well as in export containers, are offered more liberally than heretofore. But little buying interest is shown.

The situation in the *mineral acids* is strengthening, and higher prices are asked for the muriatic, nitric and sulphuric. Recent sales of the last named (the 66 deg. brimstone grade) have passed at materially higher levels than those that have prevailed for some time. One producer of sulphuric acid is now offering quantities of sulphuryl chloride on the open market.

At least one important order of 80 per cent redistilled *acetic acid* for English account is in the process of being filled. Important manufacturers are holding steadily, and some are quoting only for delivery in April and forward. The Glacial grade is not subject to any great demand although foreign orders are being held in abeyance, in the anticipation of concessions from producers. The makers, we believe, however, realize this, and are sitting tight.

Quicksilver have taken a few sharp upward jumps, owing to the facts that production and shipping to the east have been curtailed by the difficulty in carrying on mining operations during the severe weather, and the freight embargo from the west.

Glycerine was active for a few days last week, and some important orders were placed for the dynamite grade. The market has settled somewhat, and, while firm, no important business is passing in either the dynamite or c.p. grades.

Nitrate of soda has taken sensational advances, owing to the cutting down of imports, and the scarcity of resale lots.

Pharmaceuticals.—All of the bromides have been sharply reduced, owing to the absence of demand and the keen competition that has existed for many months.

All opium derivatives, due to the high cost and the absolute scarcity of this product, have advanced materially, and regular consumers are forced to pay unusually high prices.

Rochelle salts, seidlitz mixture, cream of tartar and tartaric acid have all been advanced by manufacturing chemists, owing to the scarcity of the raw materials.

Citric acid and quinine, two highly speculative articles, are subject to less pressing demand, and the second-hand market has eased off considerably.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET		FEB. 21, 1917.	
Acetone, drums	lb.	23	23½
Acid, acetic, 28 per cent.	100 lb.	3.25	3.50
Acetic, 56 per cent.	100 lb.	6.80	7.25
Acetic, glacial, 99½ per cent carboys	23	23	23½
Boric, crystals	lb.	11½	12
Citric, crystals	lb.	74	75
Hydrochloric, commercial, 18 deg.	lb.	01¼	01¾
Hydrochloric, 20 deg.	lb.	01½	01¾
Hydrochloric, C. P. conc. 22 deg.	lb.	01¾	01¾
Hydrofluoric, 30 per cent in barrels	lb.	04½	05
Lactic, 44 per cent.	lb.	11½	12
Lactic, 22 per cent.	lb.	04½	04½
Nitric, 36 deg.	lb.	04¾	05
Nitric, 42 deg.	lb.	05½	06
Oxalic, crystals	lb.	46	48
Phosphoric, 85 per cent.	lb.	28	32
Picric	lb.	65	75
Pyrogallie, resublimed.	lb.	3.50	3.75
Sulphuric, 60 deg.	lb.	\$19.00	\$22.00
Sulphuric, 66 deg.	lb.	27.00	30.00
Sulphuric, oleum (Fuming), tank cars	lb.	35.00	40.00
Tannic, U. S. P. bulk.	lb.	45	50
Tartaric, crystals	lb.	83½	84
Alcohol, grain, 158 proof.	gal.	2.72	2.74
Alcohol, wood, 95 per cent.	gal.	1.00	1.02
Alcohol, denatured, 180 proof.	gal.	.66	.67
Alum, ammonia lump.	lb.	04¼	04¼
Alum, chrome ammonium.	lb.	174	174
Alum, chrome potassium.	lb.	32	35
Alum, chrome sodium.	lb.	12	12½
Alum, potash lump.	lb.	05½	05¾
Aluminum sulphate, 18 deg.	lb.	04¾	04¾
Aluminum sulphate, iron free.	lb.	03¾	03¾
Ammonia aqua, 26 deg. carboys.	lb.	05½	05¾
Ammonia anhydrous	lb.	12½	13
Ammonium carbonate	lb.	15	16
Ammonium nitrate	lb.	04¼	04¼
Ammonium sulphate, domestic.	lb.	11	11½
Amyl acetate	gal.	3.50	4.00
Arsenic, white	lb.	25	60
Arsenic, red	lb.	11	11½
Barium chloride	ton	90.00	95.00
Barium sulphate (Blanc Fixo) powder	lb.	04¼	04½
Barium nitrate	lb.	11	12
Barium peroxide, basis 70 per cent.	lb.	27	30
Bleaching powder, 35 per cent chlorine.	lb.	03½	03¾
Borax, crystals, sacks	lb.	07	07½
Brimstone, crude	ton	28.50	29.00
Bromine, technical	lb.	1.30	1.35
Calcium, acetate, crude.	lb.	03	03½
Calcium, carbide	ton	80.00	90.00
Calcium chloride, 70-75 p. c., fused, lump	ton	23.00	24.00
Calcium, peroxide	lb.	1.70	1.75
Calcium, sulphate	lb.	01	01½
Calcium, phosphate	lb.	30	32

Carbon bisulphide.....lb.	.04	—	.04½
Carbon tetrachloride, drums.....lb.	.15½	—	.16½
Caustic potash, 82-92 per cent.....lb.	.75	—	.80
Caustic soda, 76 per cent.....100 lb.	4.25	—	4.30
Calorine, liquid.....lb.	.15	—	.16
Colalt sulfate.....lb.	.100	—	.110
Copperas.....lb.	1.10	—	1.15
Copper carbonate.....lb.	.37	—	.38
Copper cyanide.....lb.	.70	—	.75
Copper sulphate, 99 p. c. large crystals.....lb.	.09½	—	.10
Cream of tartar, crystals.....lb.	.43	—	.43½
Epsom salt, bags.....100 lb.	2.25	—	2.50
Formaldehyde, 40 per cent.....lb.	.11½	—	.12
Flauber's salt.....lb.	.100	—	.10
Glycerine, bulk, C. P.....lb.	.54	—	.55
Iodine, resublimed.....lb.	3.50	—	3.55
Iron oxide.....lb.	.02	—	.08
Lead acetate, white crystals.....lb.	.13½	—	.14
Lead arsenate.....lb.	.09	—	.09½
Lead nitrate.....lb.	.16½	—	.16½
Litharge, American.....lb.	.08½	—	.09½
Sodium carbonate.....lb.	.60	—	.65
Manganese dioxide.....lb.	.100	—	.11
Magnesium carbonate, tech.....lb.	.11	—	.11
Nickel salt, single.....lb.	.14½	—	.15
Nickel salt, bulk.....lb.	.11	—	.11
Phosphorus, red.....lb.	1.12	—	1.15
Phosphorus, yellow.....lb.	.75	—	.80
Potassium bichromate.....lb.	.37	—	.38
Potassium bromide gran.....lb.	1.00	—	1.01
Potassium carbonate calcined, 60-55 p. c.....lb.	.30	—	.32
Potassium chlorate, crystals.....lb.	.62	—	.64
Potassium cyanide, 98-99 per cent.....lb.	2.00	—	2.10
Potassium iodide.....lb.	2.00	—	2.32
Potassium nitrate, 90-90 p. c. basis of 50 p. c. ton.....410.00	425.00	—	425.00
Potassium nitrate.....lb.	.31	—	.32
Potassium permanganate.....lb.	3.75	—	4.00
Potassium prussiate, red.....lb.	2.50	—	2.55
Potassium prussiate, yellow.....lb.	2.50	—	2.55
Potassium sulphate, 90-95 p. c. basis 90 p. c. ton.....325.00	350.00	—	350.00
Rochelle salts.....lb.	.36½	—	.37
Sal ammoniac, gray gran.....lb.	.10	—	.12
Sal ammoniac, white gran.....lb.	.18	—	.19
Sal soda.....100 lb.	1.10	—	1.15
Salt cake.....100 lb.	.95	—	1.00
Silver cyanide.....lb.	.72	—	.75
Silver nitrate.....lb.	.50	—	.50
Soda ash, 55 p. c., light, flat.....100 lb.	2.50	—	2.60
Soda ash, 56 p. c., dense, flat.....100 lb.	3.45	—	3.55
Sodium acetate.....lb.	.09	—	.10
Sodium benzoate.....lb.	7.00	—	7.50
Sodium bicarbonate, domestic.....100 lb.	1.90	—	2.00
Sodium bicarbonate, English.....lb.	.03	—	.03½
Sodium bichromate.....lb.	.17½	—	.18
Sodium bisulphite, powder.....lb.	.04¾	—	.05
Sodium chlorate.....lb.	.25	—	.27
Sodium cyanide.....lb.	1.15	—	1.30
Sodium fluoride, commercial.....lb.	.11½	—	.13
Sodium hyposulphite.....lb.	.0178	—	.0178
Sodium nitrate, refined.....lb.	.05	—	.05½
Sodium nitrite.....lb.	.11	—	.11½
Sodium peroxide.....lb.	1.00	—	1.15
Sodium phosphite (tri).....lb.	.04½	—	.04¾
Sodium prussiate, yellow.....lb.	.31	—	.32
Sodium silicate, liquid.....100 lb.	1.05	—	1.25
Sodium sulphide, 30 per cent crystals.....lb.	.0278	—	.03½
Sodium sulphate.....lb.	.02½	—	.03
Strontium nitrate.....lb.	.28	—	.30
Sulphur chloride, drums.....lb.	.09¾	—	.10
Sulphur dioxide, liquid, in cylinders.....lb.	.71	—	.75
Sulphur, flowers, sublimed.....100 lb.	2.30	—	2.40
Sulphur, red.....100 lb.	1.90	—	2.00
Sulphur, crude.....ton	36.50	—	38.00
Tin bichloride, 50 deg.....lb.	.14	—	.15
Tin oxide.....lb.	.47	—	.50
Zinc carbonate.....lb.	.26	—	.27
Zinc chloride.....lb.	.13	—	.13½
Zinc cyanide.....lb.	.50	—	.52
Zinc dust.....lb.	.21	—	.22
Zinc oxide, American process XX.....lb.	.11½	—	.12
Zinc sulphate.....lb.	.06½	—	.07

Coal Tar Products (Crude)

Benzol, pure, water white.....gal.	.58	—	.60
Benzol, 90 per cent.....gal.	.56	—	.60
Toluol, pure, water white.....gal.	1.80	—	1.85
Xylol, pure.....gal.	1.00	—	1.05
Solvent naphtha, water white.....gal.	.22	—	.23
Solvent naphtha, crude heavy.....gal.	.15	—	.17
Cresote oil, 25 per cent.....gal.	.25	—	.26
Dip oil, 20 per cent.....gal.	.25	—	.26
Pitch, various grades.....ton	7.50	—	20.00
Carbolic acid, crude, 95-97 per cent.....lb.	.85	—	.90
Carbolic acid, crude, 50 per cent.....lb.	.55	—	.60
Carbolic acid, crude, 25 per cent.....lb.	.35	—	.40
Cresol U. S. P.....lb.	.18	—	.22

Intermediates, Etc.

Alpha naphthylamine.....lb.	1.00	—	1.25
Aniline oil.....lb.	.26	—	.29
Aniline salts.....lb.	.27	—	.30
Anthracene, 80 per cent.....lb.	.40	—	.40½
Benzaldehyde.....lb.	4.00	—	4.50
Benzidine, base.....lb.	1.60	—	1.50
Benzidine, sulphate.....lb.	8.00	—	8.50
Benzole acid.....lb.	.80	—	.90
Beta Naphthol, sublimed.....lb.	.48	—	.50
Dichlor benzol.....lb.	.55	—	.60
Dimethylaniline.....lb.	.30	—	.35
Diphenylamine.....lb.	Nominal	—	Nominal
H-acid.....lb.	1.50	—	1.65
Metaphenylenediamine.....lb.	.32	—	.35
Monochlorobenzol.....lb.	.69½	—	.70
Naphthalene, flake.....lb.	1.75	—	2.00
Naphthalic acid, crude.....lb.	.45	—	.50
Nitro-naphthalin.....lb.	.45	—	.50

Ortho-aminodiphenol.....lb.	1.20	—	1.30
Para-aminodiphenol base.....lb.	1.25	—	1.30
Paranitraniline.....lb.	1.20	—	1.30
Paraphenylenediamine.....lb.	3.50	—	4.00
Paratoluidine.....lb.	1.50	—	1.60
Phenol, U. S. P.....lb.	.45	—	.50
Resorcin, technical.....lb.	9.00	—	10.00
Resorcin, pure.....lb.	17.00	—	17.50
Salicylic acid.....lb.	1.40	—	1.50
Salol.....lb.	1.40	—	1.50
Sulphanilic acid.....lb.	.30	—	.32
Tolidin.....lb.	3.00	—	3.50
Toluidine-mixture.....lb.	.90	—	1.00

Petroleum Oils

CRUDE (AT THE WELLS)

Pennsylvania.....bbl.	3.05	—	3.10
Corning, Ohio.....bbl.	2.38	—	2.40
Somerset, Ky.....bbl.	2.18	—	2.20
Wooster, Ohio.....bbl.	2.05	—	2.10
Indiana.....bbl.	1.72	—	1.75
Illinois.....bbl.	1.87	—	1.90
Oklahoma and Kansas (except Healdton).....bbl.	1.70	—	1.75
Caddo, La. light.....bbl.	1.70	—	1.75
Corsicana, Tex., light.....bbl.	1.70	—	1.75
California.....bbl.	.73	—	.82

Lubricants

Black, reduced, 29 gravity, 25-30 cold test.....gal.	1.13½	—	1.14
Cylinder, light.....gal.	.21	—	.26
Cylinder, dark.....gal.	.18	—	.19
Extra, cold test.....gal.	.26	—	.31
Paraffine, high viscosity.....gal.	.29½	—	.30
Paraffine, 0.903 spec. gr.....gal.	2.11½	—	2.12
Paraffine, 0.865 spec. gr.....gal.	1.8½	—	1.9

Flotation Oils

Pine oil, steam distilled, sp. gr. 0.925-0.940.....gal.	.55½	—	.56
Pine oil, destructively distilled, sp. gr. 0.920-0.940.....gal.	.46½	—	.47
Pine-tar oil, sp. gr. 1.025-1.035.....gal.	1.94½	—	1.95
Pine-tar oil, double refined, sp. gr. 0.965-0.990.....gal.	.30	—	.30
Pine oil, light, sp. gr. 0.950, tank cars.....gal.	.35	—	.35
Pine oil, heavy, sp. gr. 1.025, tank cars.....gal.	.22	—	.22
Pine tar, thin, sp. gr. 1.060-1.080.....gal.	.19	—	.19
Turpentine, crude, sq. gr. 0.980-1.000.....gal.	.38	—	.38
Hardwood oil, f.o.b. Michigan, sp. gr. 0.960-0.990.....gal.	.16	—	.16
Hardwood oil, f.o.b. Michigan, sp. gr. 1.06-1.08.....gal.	.16	—	.16
Cresote, coal tar neutral, sp. gr. 0.990-1.010.....gal.	.14	—	.14
Cresote, coal tar, acid, sp. gr. 0.995-1.015.....gal.	1.9½	—	1.9½

Vegetable and Other Oils

China wood oil.....gal.	1.13½	—	1.14
Cottonseed oil, crude.....gal.	.79	—	.81
Linseed oil, raw.....gal.	.93	—	.93
Peanut oil, crude.....gal.	.92	—	.93
Rosin, 230 lb.....bbl.	6.30	—	6.30
Rosin oil, first run.....gal.	.38	—	.38
Rosin oil, fourth run.....gal.	.70	—	.70
Soya bean oil, Manchuria.....gal.	.13	—	.13
Turpentine, spirits.....gal.	.32	—	.32

Miscellaneous Materials

Barytes, floated, white, domestic.....ton	25.00	—	35.00
Barytes, prime white, foreign.....ton	38.00	—	40.00
Beeswax, white pure.....lb.	.52	—	.52
Carnauba wax, highest grade.....lb.	.51	—	.52
Chalk, light, precipitated, English.....lb.	.04½	—	.05
Feldspar.....ton	8.00	—	12.00
Fuller's earth, powdered.....100 lb.	.80	—	1.05
Ozokerite, crude, 15-ton lots, foreign.....lb.	.50	—	.50
Red lead, dry, carloads.....ton	10.00	—	10.4
Soapstone.....ton	10.00	—	12.50
Talc, American, white.....ton	10.00	—	13.00
White lead, dry.....lb.	.08¾	—	.09

Refractories, Etc.

(F.O.B. WORKS)

Chrome brick.....net ton	Nominal	—	Nominal
Chrome cement, Grecian.....net ton	80.00	—	90.00
Clay brick, first quality fireclay.....per 1000	40.00	—	50.00
Magnesite, Grecian, dead burned.....net ton	85.00	—	90.00
Magnesia brick, Grecian, 9 x 4½ x 2½.....net ton	135.00	—	140.00
Silica brick.....per 1000	40.00	—	45.00

Ferroalloys

Ferro-carbon-titanium, f.o.b. Niagara Falls, N. Y.....lb.	12½	—	13
Ferrocromium.....lb.	Nominal	—	Nominal
Ferromanganese, domestic, delivered.....ton	275.00	—	300.00
Ferromanganese, English.....ton	185.00	—	185.00
Ferromolybdenum, per lb. of Mo.....lb.	4.00	—	4.00
Ferrosilicon, 50 p. c. carloads, del. Pittsburgh.....ton	150.00	—	175.00
Ferrosilicon, 50 p. c. contract, del. Pitts- burgh.....ton	100.00	—	100.00
Ferrotungsten, 75-85 p. c. f.o.b., Pittsburgh.....lb.	2.20	—	2.20
Ferrovandium, f.o.b. works.....lb.	2.75	—	3.00

INDUSTRIAL

Financial, Construction and Manufacturers' News

Financial

The Air Reduction Sales Co., Inc., has been authorized to do business in Delaware, with a capital of \$25,000. The business is given as oxygen, nitrogen and liquid air. Representative M. W. Randall, 120 Broadway, New York.

The Amargosa Copper Company, Spokane, Wash., has been incorporated in Washington with a capital of \$1,000,000 by C. D. Muxen, G. A. Hinkle, and A. M. P. Spalding. American Tanning Corp., New York, has been incorporated with a capital of \$20,000 to manufacture hides, skins, leather, tan-heries. The incorporators are A. Woodcock, C. J. Kulberg, J. J. Salenker, 566 West 171st Street.

Arc Iron Works, Inc., has been incorporated with a capital of \$5,000 to engage in business in steel, iron and metals. The incorporators are J. Cohen, L. Brooks, I. Fein, 187 Sutter Avenue, Brooklyn.

Atwell Chemical Co., New Haven, Conn., has been incorporated with a capital of \$4,500. The incorporators are L. Atwell, C. F. Spaulding and S. M. Spivak.

The Auto Aid Manufacturing Co., Milwaukee, Wis., has been incorporated with a capital of \$150,000 to manufacture, sell and deal in and with chemical preparations of all kinds. The incorporators are Chas. Lehtinen, J. Lurman, John Jepsen, Jepsenting all of Milwaukee.

Boston-Miami Lead & Zinc Co., Boston, Mass., has been incorporated with a capital of \$900,000. The incorporators are A. W. Pitman, D. Blaneau, 3 Fine Street, Winchester, and G. B. Gifford.

The Brown Disinfectant & Chemical Company, Philadelphia, Pa., has been incorporated with a capital of \$85,000, to manufacture disinfectants, medical and chemical preparations of all kinds. The incorporators are Irving M. Stewart, Philadelphia, Pa., Thomas M. Brown, Charles H. S. Clifford, Wilmington, Del.

The By-Products Co., Louisville, Ky., has been incorporated with a capital of \$5,000 to manufacture chemicals. The incorporators are A. Reutlinger and Barton Fox and Walter S. Lapp.

The Calumet Mining Company has been incorporated in Utah to take over the interests of the Mines Development Company in the Iron County district, and particularly the lease and bond privileges on the Arrowhead property, 25 miles from Sahara.

Campbell & Co., Boston, Mass., has been incorporated with a capital of \$20,000 to manufacture paints, shellac, all kinds. The incorporators are E. H. Johnson, Jas. R. Flanagan, 17 Milk Street, and W. H. Rutherford.

Chemico-Minerals Corp., Yonkers, N. Y., has been incorporated with a capital stock of \$25,000 to engage in business in minerals, nitrates, etc. The incorporators are H. S. Fisher, G. Fountain, N. M. Kennedy, 140 Remsen Street, Brooklyn.

The Cleveland Chemical Company, Cleveland, Ohio, has been incorporated with a capital of \$10,000. The incorporators are B. E. Friedman and others.

Commerical Products Co., East St. Louis, has been incorporated with a capital of \$200,000 to manufacture chemicals. The incorporators are Jeffries & Corum, 1112 Central Commercial Bank Building, St. Louis, Mo.

National Dye Corp., New York, has been incorporated with a capital of \$5,000, to manufacture dyes and chemicals. The incorporators are G. W. Roosevelt, Jr., J. Descaux, J. Steiner, 75 Riverside Drive.

Comstedt & Co., Inc., Manhattan, has been incorporated with a capital of \$100,000 to deal in iron, steel, metal work, etc. The incorporators are V. H. W. Washington, 353 West 166th Street, New York City; G. L. Robinson, 647 Tenth Street, Brooklyn.

The Consumers Dye Wood Products Corporation has been incorporated with a capital of \$10,000 to engage in business in natural vegetable dyes. The incorporators are W. D. Marbourg, M. Flynn, R. L. Moffett, 471 Park Avenue.

The Truchile Clay Company of New York has been incorporated in Delaware with a capital of \$2,000,000 to acquire land containing oil, clay, coal, etc. Incorporators: Herbert E. Latter, Norman P. Coffin, and C. M. Egner, of Wilmington, Del.

H. B. Davis Co., Wilmington, Del., has

been incorporated with a capital of \$200,000 to manufacture paints, oils and other supplies.

Henry L. Doherty & Co. has formed a new \$20,000,000 company at Kansas City, Mo., under the name of The Empire Refining Company. The company will control six refineries, five of which are in Oklahoma and one in Texas. The companies which will be controlled by the new corporation will be American Refining Company, Okmulgee, Okla.; Ponca Refining Company, Ponca City, Okla.; Cushing Refining Company, Cushing, Okla.; Peerless Refining Company, Cushing, Okla.; Oklahoma Refining Company, Oklahoma City, Okla.; Producers' Refining Company, Gainesville, Tex. The six refining companies are engaged in the refining of crude Oklahoma and Texas. The Empire Pipeline Company, Leans tankage and pipe lines around the Eldorado and Augusta oil fields, which the Henry L. Doherty in these pipe lines are completed, that they will furnish the Eldorado and Augusta oil to the various refineries owned by the Empire Refining Company. The total capacity of these refineries at present is about 30,000 barrels per day.

Dragon Paper Mfg. Co., Inc., New York City, has been incorporated with a capital of \$25,000 to manufacture paper specialties, twine. The incorporators are B. G. Bernstein, G. S. and M. Bleyer, 48 West Fifth Street.

Hightower Lead Co., Joplin, Mo., has been incorporated with a capital of \$100,000.

General Graphite Co., Birmingham, Ala., has been incorporated with a capital of \$1,500,000 to mine and deal in graphite, mica, gold, silver and copper. The incorporators are J. Stanford, Clark T. Dorman, M. Ferguson, Birmingham, Ala.

Gold Chemical & Powder Mfg. Co., Inc., has been incorporated with a capital of \$5,000. The incorporators are A. Danizer, C. and J. Davis, Harrison N. J.

The Granger Products Company, Washington with a capital of \$10,000 in Wisconsin. The incorporators are H. B. Wilson, Peterson, S. H. Dickinson, and H. B. Wilson.

H. & H. Foundry Co., Stamford, Mass., has been incorporated with a capital of \$20,000 to do a foundry business. The incorporators are B. Harris, Stamford; J. Hansen, East Port Chester; C. Pond Webb, Stamford.

William Harvey Corporation has been incorporated with a capital of \$250,000 to manufacture tin, lead and barva iron, copper, gold, silver, by products. The incorporators are G. D. Dorsey, R. F. Pearce, E. J. Cornish, 111 Broadway.

Helburn-Thompson Co., Salem, Mass., has been incorporated to conduct a general tanning and leather business.

Henie, Inc., New York City, has been incorporated with a capital of \$50,000 to manufacture paraffin, petroleum greases, lubricating oils. The incorporators are W. Ward, G. R. Martin, S. Henie, 25 Beaver Street.

The Hopkins Fertilizer Co., New Albany, Ind., has increased its capital from \$50,000 to \$150,000.

Hydrocarbon Gas Co., Inc., Dover, Del., has been incorporated with a capital of \$1,000,000 to manufacture gas machinery, merchandise. The incorporators are O. U. Bear, 45 Broadway, Manhattan.

Hygeine Manufacturing Co., Dallas, Tex., has been incorporated with a capital of \$26,000 to manufacture chemicals and by-products thereof. The incorporators are E. E. Ballard, A. A. Clarke and H. C. Jarrell.

Inland Steel Co., Dover, Del., has been incorporated with a capital of \$30,000,000 zinc and metallic compounds of all kinds. The incorporators are Herbert E. Latter, Norman P. Coffin and Clement M. Egner, all of Wilmington, Del.

International Manganese Co., Portland, Me., has been incorporated with a capital of \$2,000,000 to deal in general mining, quarrying, smelting, preparing for market, etc., all kinds of metals, ores, minerals, etc. The president is William M. Riddle, Boston, Mass.

The Jakes Foundry Co., Nashville, Tenn., has been incorporated with a capital of \$10,000. The incorporators are Robert

Jakes, J. W. Jakes, E. F. Jakes Robert Jakes, Jr., and Lee Parish.

The Victor E. Knecht Foundry Company, Harrison, Ohio, has been incorporated with a capital of \$6,000. The incorporators are Victor E. Knecht and others.

The Lead Queen Mining & Milling Company, Spokane, Wash., has been incorporated in Washington with a capital of \$1,000,000 by T. D. Heav, A. S. Nichols, Louis Morgan, E. M. Steele and A. C. Shaw. The Lehigh Valley Coke Company interests, which were held by the Berlin Anhalter Machine Construction Co., the Stettinger Channotte Co., are understood to have been sold to the Bethlehem Steel Co. for \$7,000,000.

The Lincol Products Company, Seattle, has been incorporated in Washington with \$50,000 capital by Ben M. Harris, J. A. Reubens and C. Newman.

The Marion Glass Manufacturing Co., Marion, Ohio, has been incorporated with a capital of \$50,000. Incorporator, G. L. Kratz.

Missouri Plate-Glass Co., St. Louis, Mo., has been incorporated with a capital of \$1,500,000 to manufacture and sell glass. The incorporators are R. Francis, Herculaneum, Mo.; E. Baumann, C. B. Johnson and R. R. Baumann.

H. C. Mooney Co., 68 Chestnut Street, Newark, N. J., has been incorporated with a capital of \$10,000 to manufacture paper, paper products, etc.

New Jersey Dye Stuffs, corporation, Paterson, has been incorporated with a capital of \$25,000 to manufacture dye stuffs, etc. The incorporators are Rudolph Schroeder, Robert Rueser and Nathan Marcus, of Hoboken.

New York Dye Stuffs Co., Inc., Brooklyn, N. Y., has been incorporated with a capital of \$10,000 to manufacture felts. The incorporators are H. S. Schamel, B. Diamond, M. Spiewack, 1213 Forty-first Street, Brooklyn.

The New York Quinine and Chemical Works, Ltd., New York, has reduced its capital from \$294,000 to \$10,000.

The Ohio Copper Co., Utah, with a capital of \$2,500,000, has filed application for business rights in Utah. The company was incorporated originally in Maine. Stanley B. Sherman is president.

Ohio Mold and Foundry Co., Cincinnati, Ohio, has increased its capital from \$100,000 to \$150,000.

The Old Dominion Chemical Company, of Yorktown, Va., has been chartered, with \$275,000 capital. Officers are: Andrew D. Christian, president; E. S. Bolen, secretary-treasurer, both of Richmond, Va.

Park Utah Mining Co., New York, has been incorporated with a capital of \$1,250,000 to carry on a general mining business. The incorporators are H. L. Nehring, N. Y., Jas. F. Rogan, Brooklyn, and Frederick Hilderbrand, Tompkinsville, N. Y.

The Piqua Bleachery Co., Piqua, Ohio, has been incorporated with a capital of \$10,000. Incorporators are G. R. Fairborn, W. D. Frye, James Farley. Ladium Chemical Company, has been incorporated with a capital of \$750,000 to manufacture everything in tin and chemicals also to manufacture tin containers, to obtain formulas to manufacture and sell all articles. The incorporators are: President, L. J. Coleman, Augusta; treasurer, M. F. Herlin, Augusta; clerk, C. L. Andrews, Augusta; directors, L. J. Coleman, E. B. Turner and M. F. Herlin, all of Augusta.

Rainy River Pulp Paper Co. has been incorporated with a capital of \$1,000,000 to operate lumber mills, pulp and paper mills. The incorporators are J. J. Sweeney, J. M. Bengier, Spokane, Wash.; H. L. McNair, Wallace, Idaho.

United Distributing Company, Paterson, N. J., has been incorporated with a capital of \$50,000 to manufacture chemicals of all kinds. The incorporators are Richard S. Coffax of Pompton, and Henry M. Van Buren and Joseph E. Lambert of Paterson.

The Rocmac Company, 972 Building, Cleveland, Ohio, has been incorporated under the laws of Ohio to market Rocmac, a liquid, elastic binder used for highways. The company will maintain a complete laboratory for testing materials to be used in connection with Rocmac.

The Scrap-N-Mac Chemical Company, Cincinnati, Ohio, has been incorporated with a capital of \$10,000. Incorporators are Earl S. Hall, George J. Boehm, Miriam Saddy, Alice C. Roudeshush, Allen P. Lockwood.

Sinclair Central American Oil Corporation, New York, has been incorporated with a capital of \$5,000,000. The incorporators are A. J. Gatherers, F. J. Thompson, H. Thomson, 37 Wall Street, Manhattan.

Southern Carbon Co., Wilmington, Del., has been incorporated with a capital of \$450,000, to deal in carbon and gas. The Spokane-Benton County Natural Gas Company, Spokane, has been incorporated in Washington by Herbert C. Harris, J. B.

Valentine and John McGonigle. Capital \$1,500,000.

The Standard Oil Company of Indiana has increased its capital from \$30,000,000 to \$100,000,000.

Taylor Coupler & Steel Castings Co., Toledo, Ohio, has been incorporated with a capital of \$100,000. The incorporators are J. C. Taylor and L. C. Dukes.

The Tiemann Chemical Company, Inc., of New York City, has been incorporated with a capital of \$50,000. Adolph Hosch, Brooklyn, is a director.

The Warren Lubricating Co., Buffalo, N. Y., has been incorporated with a capital of \$50,000. The incorporators are vegetable oils and petroleum. The incorporators are M. M. Sanderson of Buffalo, A. J. Squier of New York City and H. N. Squire of Scranton, Pa.

The Western Tale Company, Everett, Wash., has been incorporated in Washington with \$100,000 capital by Douglas F. Smith, K. I. Kobbering and George W. Stryker.

Winchester Hayden, Powell, Inc., has been formed in Massachusetts with a capital of \$50,000. The officials are Howard L. Winchester, president; Samuel H. Hayden, treasurer, and William A. Powell, vice-president. Mr. Winchester was one of the leading factors in the financing of the Iron Cane Copper Company, and recently financed the Gold Cup Mining Company, having been elected president in December last. Mr. Hayden is a manufacturer of Haverhill. William A. Powell is for 15 years managing editor of the Boston Financial News. The business of the company will principally consist of financing and managing mining and industrial enterprises.

Worth Steel Co., Coatesville, Pa., has been incorporated with a capital of \$2,500,000 to manufacture, deal in and with iron, steel, manganese, etc. The incorporators are W. P. Worth, H. H. Worth, W. A. Worth, N. T. Entrekin, all of Coatesville.

The Yellowstone Gold Mining Company, Spokane, has been incorporated in Washington with a capital of \$300,000 by William Carr, and Alfred J. Carr.

Brigham Young, Jr., Wilmington, Del., has been incorporated with a capital of \$5,000 to manufacture, sell and deal in and with patent medicines, drugs, chemicals, etc. The incorporators are C. Fearon, K. M. Dougherty, E. Lynch, all of Wilmington.

Construction and Operation

Arizona

JEROME.—The United Verde Extension Company has appropriated \$2,500,000 for the company's new smelting plant at Cottonwood on the Verde River. Additions to the Clarkdale smelter will enable that plant to start out 6,500,000 lb. of copper per month during 1917.

California

LOS ANGELES.—A Mr. Hienz of San Francisco has purchased a sugar factory at Waverly, Wash., and will move the machinery to Los Angeles where a new factory will be erected.

PITTSBURG.—The Great Western Electrochemical Company is making additions to its plant which will give it an increased capacity of 25 per cent. The manufacture of other chlorine products will be taken up in addition to the caustic soda and bleaching powder.

SAN FRANCISCO.—The Crockett refinery of the California & Hawaiian Sugar Company will be enlarged at a cost of \$2,500,000. The work will take two years to complete and will increase the refining capacity from 300 to 1300 tons per day.

SAN FRANCISCO.—Mr. P. S. du Pont of the Du Pont Company recently made a visit to California. It is understood that examinations are being made with a view to establishing a potash plant manufacturing potash from seaweed.

Connecticut

BRISTOL.—The Bristol Brass Company will soon begin work upon two new factory buildings, one of which will be used as an addition to the casting plant.

DERBY.—The mill of the old Derby Paper Company, recently damaged by fire, is being repaired and will be occupied by a company headed by Joseph Willmann, president of the Derby Manufacturing Company. The new company will manufacture crucibles or melting pots for brass.

WATERBURY.—The Chase Metal Works

Corporation will erect four factory additions to its plant.

Delaware

NEW CASTLE.—The Deemer Steel Casting Company will make improvements to its plant costing about \$30,000.

The Belmont Iron Company will construct an addition to its foundry.

Georgia

SAVANNAH.—The American Sugar Refining Company has considered a location for a proposed \$5,000,000 plant here. Savannah is considered a good location on account of shipping facilities to Cuba.

Illinois

JOLIET.—The Keystone Steel & Wire Company will erect a plant here. Mr. Julian Kennedy of Pittsburgh is engineer in charge of the design and construction. Mr. Barton R. Shover, formerly superintendent of the Erie Hill Steel Company, has been retained as electrical engineer on the power equipment.

Indiana

ATTICA.—The Harrison Steel Company will erect a \$300,000 steel castings foundry. Mr. J. W. Harrison, president of the National Car Coupler Company, will be in charge of the erection.

Kentucky

LOUISVILLE.—The Hopkins Fertilizer Company of New Albany has increased its capital from \$50,000 to \$150,000 and will use the increased capital in additions and improvements.

LOUISVILLE.—A syndicate of New York capitalists, headed by A. B. Benisch, is reported to have bought for \$400,000 the property of the Kentucky Refining Company in Louisville, which has been in liquidation for the past several years. The syndicate proposes to establish a refinery there for crude oil from the Irvine, Ky., field, according to reports from that place.

The Kentucky Refining Company's plant is located at 1303-1333 South Shelby street, and was formerly used as a cotton seed oil refining plant. The entire property embraces almost six acres of ground, and is improved with several large buildings. Part of the property, including machinery and rolling stock, was sold to Campbell, Heath & Co., bankers of New York City, by the creditors' committee, of which Embury L. Swearingen was chairman. An option was given on the balance of the property, including the real estate.

An official of the Standard Oil Company said nothing had come to his knowledge of such a deal, and that in view of the character of the Kentucky Refining plant it did not seem to be available for petroleum refining. This process requires great acreage owing to the necessity for large and numerous storage tanks for both refined and crude oil.

Louisiana

MONROE.—The Columbia Carbon Company, of Monroe, La., will erect a plant at Spkyer, La., to manufacture carbon and other products of natural gas, and has contracted with the Progressive Oil & Gas Company of Monroe for 2,000,000 ft. of gas daily. Its capital has been increased from \$75,000 to \$200,000.

NEW ORLEANS.—The National Smelting & Refining Company has begun construction of a \$25,000 smelting plant on a site recently purchased here. It is located at Greenwood Avenue and the Illinois Central Railroad. The company will manufacture type metal, babbit metal, and ingot products of various other metals.

Maine

BANGOR.—The new pulp bleaching plant being erected by Eastern Manufacturing Company at its big plant in South Brewer is practically completed. The new building is located just north of the present main pulp mill between the mill and the electrochemical plant erected last spring.

Maryland

BALTIMORE.—The American Refractories Company will move its plant from Joliet, Ill., to Baltimore. The company will manufacture glass which refracts light, including telescopes, dark bottles and prism. The sand and other raw material come from Austria and it was for this reason that the company located in Baltimore. The plant

will cover about 20 acres and it is believed that the factory will be ready for operation by the time shipping facilities become normal again.

BALTIMORE.—The International Pulp & Wood Company will shortly begin the erection of a large factory on Franklin Street to cost about \$40,000.

BALTIMORE.—The Bethlehem Steel Corporation according to an announcement made by Charles M. Schwab plans the erection of a \$40,000,000 plant here which will be the largest on the Atlantic Coast.

Massachusetts

ADAMS.—The Berkshire Hills Paper Company will double the capacity of the present plant by the addition of a second unit. A new beater and drainer building, a new engine and power house, and a new finishing department will be erected.

SPRINGFIELD.—Mr. Paul M. Kluger of Springfield, and Mr. Albert Jacob of Rochester, N. Y., are planning the erection of a foundry at East and Ferry Streets.

WALTHAM.—A license has been granted to the National Product Company to conduct an oil distilling plant at Roberts and for storage of 50,000 gal. of oil in underground tanks. The local Board of Health had a long discussion over this, but finally decided to grant a license, provided no gas be allowed to escape. A report on the project was made by Dr. Arthur D. Little of Boston.

Michigan

SAGINAW.—The Saginaw Malleable Iron Company, recently organized with a capitalization of \$350,000, is completing plans for a factory, suitable for producing 12,000 tons per year. It will employ about 450 men. Mr. C. F. Drozetzki has secured his connection with the Illinois Malleable Company to become manager of the Saginaw Company.

Minnesota

ST. PAUL.—Reported Northern Star Rubber Company, New York, Life Building, plans erecting factory building in Midway district to cost from \$175,000 to \$230,000.

Mississippi

HATTIESBURG.—The Hattiesburg wood reduction plant, which has been closed down for some time, will renew operations in the very near future. It was announced recently. This plant was built at a cost of about \$100,000, and had never been operated to the satisfaction of the stockholders. They had manufactured turpentine and its by-products, but had not installed machinery to extract rosin from pine knots and stumps. Recently the Dantzler interests at Moss Point became interested in the proposition to the extent of buying stock and taking charge of the plant. They now have a number of skilled workmen at the plant getting the machinery in working condition and in the near future will have the plant going at full blast. The plant will use possibly fifty cords of wood each day and will employ a large number of men in addition to giving a market for pine stumps, knots, etc., with which the cut-over lands of Mississippi are literally covered.

Missouri

EAST CARONDELET.—The Roxana Petroleum Company plans the construction of a pipe line from the Oklahoma wells to St. Louis and the erection of a large refinery at this place.

ST. LOUIS.—According to advices from Washington the government is contemplating taking over carbon manufacturing plants. This would affect one factory in the St. Louis district; the American Carbon & Battery Company of East St. Louis. The plant has 15,000 flash-light batteries and No. 6 cells a day. The Government would use the plants to equip the navy with flashlights and dry batteries.

Montana

ANACONDA.—The Ohio Copper Mining Company has decided to install the flotation process for handling its slimes. A report reads as follows:

The Ohio Copper Mining Company has ordered old flotation equipment for the treatment of 150 tons of slimes daily from the present mill. The present mill is handling 2000 to 2200 tons of ore per diem, and the slimes from this tonnage amount to about

60 tons daily. The mill is recovering between 40 and 45 per cent of the values in the ore. The ore, and more particularly the copper in the ore, slimes excessively and the values in the slimes have heretofore been largely lost by water concentration. Oil flotation was recommended in 1913 by M. W. Atwater, but the recommendations were not followed by the former management. With oil flotation it is expected that recoveries may improve to 60 or 70 per cent, and some optimistic estimates even figure 80 per cent. The ore runs about 1 per cent copper. The new management proposes to increase milling capacity to 3000 tons daily."

LIBBY—Hazel-Luckens silver and lead mine will erect mill to cost \$150,000.

New Jersey

HARRISON—The new plant being erected by Reuther Bros. on Seventh Street, Harrison, will consist of a main foundry and several buildings.

NEWARK—The Indian Refining Company, which has a plant on the Kearny Meadows, will erect a \$200,000 addition, including 20 tanks.

The Egyptian Lacquer Company will erect an office building, boiler house and distilling plant to cost \$50,000 at its plant in Passaic Avenue.

NEWARK—The Central Dye Stuff & Chemical Company has commenced erecting a four-story warehouse, 75 x 129 ft. This is the latest addition to the large group of buildings which this firm has built during the last two years. Dr. George Prochaska is president of the company.

NEWARK—The Martin Dennis Company, 359 Sumner Avenue, manufacturer of tanners' chemicals, has increased its capital from \$600,000 to \$1,000,000 for extensions.

NEWARK—The General Leather Company will build a one-story addition, 28 x 114 ft., to its plant at 423-38 Frelinghuysen Avenue, for the manufacture of bleach liquor. The addition will cost \$15,000.

NEWARK—The Gerhard Menken Chemical Company, 42 Orange Street, has increased its capital from \$50,000 to \$1,000,000 for extensions.

New York

BROOKLYN—De Voe & Reynolds, Fulton and William Streets, New York City, N. Y., headquarters, paint manufacturers, has awarded the American Concrete Steel Company the general contract for the erection of a \$100,000 factory at Huntington, Smith and Ninth Streets. The building will be two stories high, 100 x 100 ft., of reinforced concrete construction.

DUNKIRK—The Atlas Crucible Steel Company will erect a large electric furnace foundry on Howard Avenue.

DUNKIRK—Mr. Fredericks, formerly manager of the Dunkirk Glass Company, plans the erection of a \$100,000 plant directly opposite the plant of the Dunkirk Glass Company.

Ohio

AKRON—The United States Steel Corporation has purchased 800 acres of land near Akron for the erection of a large steel plant, according to a report.

CINCINNATI—The Ohio Mold & Foundry Company of Pittsburgh has purchased the plant of the Lane & Bodley Company, of Bond Hill. It will make ingot molds for use in steel mills.

CINCINNATI—Linde Air Products Company of New York has received a permit to erect a one-story factory to cost \$45,000. The factory will be used for manufacturing oxygen.

COLUMBUS—The Standard Glass Products Company of this city is equipping a plant to make various kinds of glass lamps and laboratory and chemical glass. Mr. J. Z. Krum is one of the incorporators.

COLUMBUS—The Federal Chemical Company of Louisville, Ky., has purchased a site at Bonham Avenue and Pennsylvania Railroad and plans a factory to cost \$125,000 for manufacturing dyes.

COLUMBUS—The Columbus Glass Products Company, a new company which will manufacture glass for laboratory use, has commenced operation.

COLUMBUS—The Perry Chemical Company has recently been organized by a number of Columbus capitalists and engineers. Experiments which have been conducted with salt water occurring in the Niagara limestone formation of Athens and Perry counties, in the production of salt, calcium chloride and bromine, resulted in the formation of the company. An experimental plan is located at New Straitsville.

Plans are being prepared for the erection of a number of adequate buildings. Edmund De Mott is president of the concern and J. H. Joseph is vice-president.

MARION—A \$250,000 glass plant, to manufacture various kinds of ware will be located in Marion. This announcement came from the Chamber of Commerce. Mr. Geo. W. Moore of Pittsburgh, is president of the company.

MINERAL RIDGE—The Ohio Steel Products Company plans a large addition to its present plant. The firm manufactures steel tubing.

YOUNGSTOWN—The Basic Steel Company, a subsidiary of the Deforest Sheet & Tinplate Company, will erect a steel plant here in the near future. The Deforest Company requires about 80,000 tons of raw steel annually, and the Basic Company's plant will be built to help supply this.

STEUBENVILLE—The United States Steel Casting Company, capitalized at \$1,000,000, has been recently organized and has taken over the National Steel Casting Company of New Cumberland. The company contemplates a number of new foundries in this section.

Oklahoma

BARTLESVILLE—The Mid-Continent Gasoline Company plans to expend \$2,000,000 in building a power plant to furnish power and light for the oil fields of Oklahoma. It is expected that this will be followed by a general movement to electrify the oil fields doing away with gas engines in pumping gas and using motors. The company expects to greatly increase its output of casing head gasoline in the near future.

MIAMI—The First National Mining Company has let a contract for the erection of a 100,000 sq. ft. mill at Miami, Oklahoma City is president of the company.

SAND SPRING—The Great American Refining Company, capitalized at \$10,000,000, is seeking a suitable site in the Mid-Continent field for a large refinery. This will be the fourth refinery planned by this company.

Pennsylvania

ALLENTOWN—The Atlantic Potash Company has purchased the old plant of the Northampton Cement Company at Stockerton, and is making repairs to improve it and will operate in the near future.

CARBONDALE—The Griebel Instrument Company has purchased a property on the Erie street and will alter same and convert it into a plant for manufacturing thermometers and chemical supplies.

HARRISBURG—One of the largest open hearth furnaces in the United States is open in the course of erection at the Central Iron & Steel Company plant, where a large addition that will greatly increase the production of steel is under way. This furnace will be able to dump 150 tons of steel at each heat. The usual tonnage for furnaces is about 50 tons, according to steel experts. Workmen also are rebuilding the plant's blast furnaces and extending gas producers. A new 150 ton crane, needed to take care of the proposed increased output, has just been put in operation. What is known as Paxton furnace No. 2 is being reconstructed along modern lines. Under a contract let to the Bethlehem Steel Company a large building approximately 180 ft. long is being erected to take care of the business. This and the other improvements planned by this South Harrisburg company are expected to be ready by May 1.

PHILADELPHIA—E. J. Lavino & Company, Philadelphia, have purchased the old Vesta furnace formerly operated by the Susquehanna Iron Company. The plant will be remodeled and rebuilt and equipped for the production of manganese.

PHILADELPHIA—The American Metal Works will erect a two-story factory, 42 by 113 ft., at Loudon Street and Stenton Avenue.

PHILADELPHIA—The American Metal Works is erecting a two-story brick addition, 40 x 110 ft.

PHILADELPHIA—Rohm & Hass will build a two and one-half-story addition, about 32 x 52 ft., to their chemical plant at Bristol Pa.

POTTSTOWN—The Nagle Steel Company has purchased from the Potts Brothers Iron Company its property at Oiltown, Pa. Improvements will be made to the mill.

READING—The Reading Chemical Company is planning for extensions to its plant at North Reading for the manufacture of medicinal chemicals and dyes. The company has recently increased its capital from

\$200,000 to \$1,000,000. E. H. Deysher is president.

VANDERGRIFT—The United States Steel Corporation plans improvement amounting to \$1,000,000 to its plant here. D. A. Barrett, formerly superintendent of the Aetna-Standard plant, is the head of the plant which is one of the largest sheet mills owned by the company.

Tennessee

NEWPORT—A Cincinnati engineer has been making tests and samples of manganese and iron ore, and it is expected that a \$500,000 plant will be erected here in the near future, to smelt this ore.

Washington

ABERDEEN—Mr. R. S. Talbot of the Inland Empire Pulp & Paper Company of Spokane, Wash., is heading a project which contemplates the erection of a \$750,000 paper mill, which will have a capacity for 50 tons daily.

SEATTLE—The Seattle Brewing & Malting Company is trying out experimentally the Cazolano process for extracting alcohol from beer. Mr. Heinrich Schweitzer is chemist.

SEDRÖ WOOLLEY, The Washington Steel & Iron Company, with offices at Spokane, has ordered equipment for a plant which will cost about \$30,000 to smelt pig iron. Mr. O. L. Moore is manager. The furnaces will be oil burning, and it is considered to be somewhat of an experiment.

West Virginia

CHARLESTON—The new plant being erected at South Charleston by E. C. Klipstein & Sons Company of New York City is being rushed to completion. The plant will be used for the manufacture of dyes and is expected to be ready in the spring. The main or manufacturing building will be four stories high and 60 x 120 ft. and size laboratory has also been provided for.

WHEELING—The Wheeling Chemical Products Company, with offices at Thirty-first and Jacob Streets, will have a daily capacity of 40,000,000 matches, 1500 lb. of glue, 1000 lb. of paste and 1000 lb. of nitrated products. It is also building its own machinery and will occupy the quarters formerly used by the Unedea Brewing Company. The officers are: A. Schramm, president; H. C. Kalbeter, vice-president; E. S. Romine, secretary, and O. V. Snyder, manager.

Wisconsin

MILWAUKEE—The Hercules Steel Casting Company, a new concern capitalized at \$400,000, will erect a large plant, 500 x 70 ft. The incorporators of the company are F. E. McIntyre, E. F. Gennrich and Dr. J. J. McGovern, all of Milwaukee.

Manufacturers' Notes

ANNUAL MEETING OF GREAT WESTERN ELECTROCHEMICAL—The following directors were elected for this year at the annual meeting of the Great Western Electrochemical Company of Pittsburgh, California: Franklin Remington, H. A. Wilson, Clem Bowen of Detroit, John F. F. Mortimer, Fleishhacker, Sigmund Stern, Herbert Fleishhacker and Arthur Lillenthal.

At a special meeting the following officers were elected: Mortimer Fleishhacker, president; John F. Bush, vice-president and general manager, and Arthur Lillenthal, secretary and treasurer.

Its average output of products in 1916 were very heavy on the actual paid up cash capital of \$600,000.

At the annual meeting a report was read showing that the plant was operating at its full capacity and producing 40 tons of caustic soda and bleaching powder a day.

The stockholders unanimously ratified the proposition of the directors to increase the capacity of the plant forthwith and an order has been placed with the General Electric Company for new equipment which will increase the output of the products now manufactured about 25 per cent.

The stockholders also approved the plan of embarking on the manufacture of liquid chlorine, carbon tetrachloride and chlorate of potassium. These crude chemicals are largely used in oil refining, in the manufacture of matches, in the manufacture of powder and for mining purposes. None of

them has ever been made before on a commercial scale on the Pacific Coast.

In order to provide capital for the enlargement of the plant and its new manufacturing department, it was decided to raise \$500,000 of additional capital and to offer at once the \$400,000 of 7 per cent cumulative preferred stock now in the treasury at par to the present stockholders.

ALLEGED CONTAMINATION OF SAGINAW RIVER BY CHEMICAL PLANTS.—Investigations are under way following complaints of acid and other contaminating substances in the Saginaw River, Michigan. It is expected the action will be taken against all chemical plants in the valley, restraining them from emptying contaminating substances into the river.

ABANDONED RAILROADS PURCHASED.—The Idaho Southern Railroad which runs from Gooding to Jerome, Idaho, and the Milner & North Side Railroad, a short line extending from Milner to Oakley, Idaho, comprising a total of approximately 50 miles, have been purchased by the Walter A. Zelnick Supply Co. of St. Louis, Mo.

These railroads were built only a few years ago by Pittsburgh capital. It is understood the Walter A. Zelnick Supply Co. will dismantle the roads and sell the rails and other material.

CHEMICAL FUNNELS.—The Cambridge Glass Co., Cambridge, O., has been making improvements in the manufacture of chemical funnels and has been able to reduce the prices on these funnels considerably. The funnels are manufactured to take the place of those formerly imported.

TITANIUM ALLOY CO. CHANGES NEW YORK HEADQUARTERS.—The New York office of the Titanium Alloy Manufacturing Company, of Niagara Falls, N. Y., has been moved from 15 Wall Street, to the City Investing Building, 165 Broadway.

LARGER SAN FRANCISCO OFFICE FOR WILLIAMS CO.—The Williams Patent Crusher & Pulverizer Co., of St. Louis, Mo., have taken larger quarters for their San Francisco office at 47 Second Street, San Francisco. The San Francisco office, which has been in charge of Mr. O. J. Williams for a number of years, has developed a very satisfactory trade among the ranches for the Williams alfalfa grinder. The new quarters are larger and more centrally located and are connected with a warehouse in which the Williams company maintains a complete stock of spare parts for different types of their grinders.

STEEL-HARDENING COMPANY EXPANDING.—The St. Louis Steel-Hardening Process Co., St. Louis, Pa., many manufacturers of processed steel castings, is planning expansion of its business and has appointed Mr. F. Lloyd Mark western sales manager for the central and near western states, with office at 723 Monadnock Building, Chicago.

BARTSTOW MANAGEMENT ASSOCIATION FORMED.—W. S. Bartstow & Co., New York, announce the incorporation of the Bartstow Management Association, 50 Pine Street, New York, which will supervise the management of all public utility properties controlled by the General Gas & Electric company, the Eastern Power & Light Corporation and W. S. Bartstow & Company, Inc. Mr. E. L. West has been elected president of the new corporation.

PRODUCTION OF ALUMINUM IN 1916.—The domestic consumption of aluminum in 1916, according to estimates made by J. M. Hill, of the United States Geological Survey, was over 121,000,000 pounds. The estimates are based on the increase in domestic production for the year and of the imports for 9 months. This is an increase of more than 21 per cent over the consumption of 1915. The estimates do not include the consumption of secondary aluminum obtained from scrap materials, which is believed to have also increased.

NEW TIN PRODUCER.—The following letter was written by the president of the American Tin & Tungsten Company, to the editor of the American Metal Market:

Sir: Our company lately organized under the laws of the State of South Dakota, is now operating the only tin mine in the United States, mining, milling and smelting cassiterite tin ores. Our mill was completed about January 1st, and is now operating on tin and tungsten ores and doing custom work for neighboring mines on tin and tungsten.

The mill has a capacity of about 200 tons at the present time, for which we have sufficient capacity. According to reports to engineers reports to run at full capacity, exclusive of the custom ore offered for an indefinite period.

The ore runs about 60 per cent in metallic content, according to a recent letter from

the American Smelting & Refining Company, who have offered to take our entire mill product in concentrates. This product runs 73 per cent, with practically no impurities.

The stock has been sold to St. Louis business and professional men and is entirely a St. Louis institution.

We purchased the property, mill and good will of the Hill City Tungsten Production Company, who developed these properties up to the point where they would show constant production. The mill has been consumed within the last 30 days.

Some shipments of pig tin have been made to the St. Louis market and we expect to be a factor in the tin producing division of the United States within a short time.

We expect to shortly make application to list the stock on the New York Curb. We have about 500,000 shares of stock in circulation, which is intended to be used in further development of the properties.

American Tin & Tungsten Co.,
St. Louis, Mo., February 12, 1917.

A CENTURY OLD CIRCULAR.—One of the geologists of the Geological Survey found the following interesting "preparedness" circular among some of the papers of Thomas Jefferson, which is dated February 17, 1809, and was issued by a Philadelphia firm of type founders. The circular reads as follows:

The present state of the commerce of the United States, arising out of the conduct of the belligerent powers, having shown our wants, and pointed out the necessity of calling to our aid such of the natural productions of the country as knowledge and research might enable us to discover; with a view to this important object, we particularly solicit your attention to the articles of printing, which are essential in the manufacture of Printing Types, and which has not hitherto been discovered in this country. Bismuth would also be a great acquisition, and profitable to the owner of the mine. As it is highly probable that articles, which abound in so many parts of Europe, are not totally wanting in this extensive country, we earnestly request you to make the necessary inquiries in your neighborhood, and should you discover anything which promises a favourable result, to transmit an account of it to us.

We are respectfully,
BENJ. B. GINN & RONALDSON,
Comptrolers & Letter Founders.

GRAPHITE IN TEXAS.—Dr. William B. Phillips, who has returned from Burnet and Llano Counties, where he examined the graphite deposits, said the deposits were wonderful and he is confident they can be made the basis of a considerable industry. In speaking of the graphite deposits in Burnet and Llano Counties, Dr. Phillips said:

"These deposits are of an extraordinary character with respect to quantity and quality. They could be made the basis of a graphite industry. There is an active demand for nearly all varieties of graphite and prices are good. During the five years ending with 1914 the production of all kinds of graphite in the United States was 29,496 tons, valued at \$1,462,365. During this same period the production of artificial graphite (made by electrical processes from a certain kind of anthracite coal) was 30,138 tons, valued at \$1,111,390. During these same five years the imports of graphite were 122,461 tons, valued at \$8,576,710. Our production of natural and manufactured graphite fell short of our imports by 71,577 tons in weight and \$3,102,955 in value. It is easy to see, therefore, the reason for the graphite being so scarce in this country. We promise to augment the domestic supply. This is particularly true of flake, or crystalline graphite, the variety that always commands the highest price."

"The principal factor in the value of the Burnet and Llano graphite is that it is of the crystalline variety. It occurs in flakes of varying sizes in the older schists and gneisses of the central mineral region and comprises from 8 to 10 per cent rock. Now and then larger masses of much better grade are found, but with 8 to 10 per cent of flake graphite as they yield there is no reason to complain. As with quicksilver, so with graphite, the Texas grade material runs higher in value than elsewhere in the country. Furthermore, most of all, of the principal Texas localities are almost free from black mica, the presence of which, with graphite, renders the concentration and purification of the graphite more difficult and costly. If nature had set out to make a deposit of graphite that would yield the best possible product, she could hardly have done better than she has in the Burnet and Llano districts. Enormous quantities of a crude material exist carrying from 8 to 10 per cent of flake graphite and of the cleanest good, and excellent weather and a market already assured."

"There are less than ten establishments in the entire country making flake graphite, three or four in Alabama, two in New York, one in Pennsylvania and one in Montana. All of these, together with the plant at Niagara Falls, making artificial graphite, do not begin to supply the demand for graphite. For every ton of natural graphite produced we import from five to six tons."

Manufacturers' Catalogs

CHARLES MUNDT & SONS, 53-65 Fairmount Ave., Jersey City, N. J. have issued a little book containing illustrations of the different sized perforations which can be made on metal or other material as required.

FIRE DETECTING WIRE CO., Inc., 101 Park Ave., New York City have issued a line of the booklet "Fire Detection," describing the Fire Detecting Wire System.

GORDON ENGINEERING CORPORATION, 96 Broadway, New York have issued cards describing their standard compartment drier for drying chemicals, colors, paints, leather, rubber, etc.

ROBINSON CLAY PRODUCT CO., Akron, Ohio have issued catalog D, which illustrates specialties in the clay products were used in chemical industries, laboratories, etc., which are regularly required in the chemical industry.

HERMAN A. HOLZ, Church Street, New York City has issued a booklet of the Erichsen Machine for Testing Metal Sheets.

THE PFAUDLER CO., Rochester, New York has issued a booklet on glass-enamel and enamel apparatus. It is entitled Chemical Trades, Bulletin C-4.

MONARCH ENGINEERING & MFG. CO., 1206 American Building, Baltimore, Md. have issued a booklet entitled "Crucible Problem Solved," describing Monarch smelting and heating furnaces without crucibles.

ALUMINIUM-ALLOYS STEEL COMPANY, Pittsburgh, Pa. has issued a folder descriptive of its Vasco Special, Vasco Electric and Vasco Latrobe Carbon Tool Steels.

STEVENS BROTHERS, 149 Broadway, N. Y. has issued a loose leaf catalog of its chemical equipment of metal.

Other New Publications

FAILURE OF BRASS.—1-Microstructure and Initial Stresses in Wrought Brasses of the Type 60 Per Cent Copper and 40 Per Cent Zinc. By Paul D. Merica and R. W. Woodward. Technologic Paper of the Bureau of Standards, Bulletin No. 82 issued by the Department of Commerce, January 25, 1917.

COLORIMETRIC TEST FOR ORGANIC IMPURITIES IN SANDS.—By Duff A. Abrams and Oscar E. Harder. Circular No. 1 of the Standard Materials Research Laboratory With the Cooperation of the Portland Cement Association and Lewis Institute, Chicago, issued February, 1917.

CHECKER IN 1915.—By Frank L. Hess, issued by the Department of the Interior, Geological Survey.

PHYSICAL AND CHEMICAL PROPERTIES OF GASOLINES SOLD THROUGHOUT THE UNITED STATES DURING THE CALENDAR YEAR 1915.—By W. F. Rittman, W. A. Jacobs and E. W. Dean. Technical Paper 163, Petroleum Technology 38, issued by the Department of the Interior, Bureau of Mines, November, 1916.

REFINING AND UTILIZATION OF GEORGIE KAOLINS.—By Ira E. Sprout. Bulletin 128, Mineral Technology 18, issued by the Department of the Interior, Bureau of Mines, October, 1916.

COBALT ALLOYS WITH NON-CORROSIVE PROPERTIES.—By Herbert T. Kalms and K. E. Blake. Part of a series of books published by the Canada Department of Mines, Branch, Ottawa, Canada, 1916. No. 411, dealing with researches on cobalt and cobalt alloys, conducted at Queen's University, Kingston, Ontario, for the Mines Branch of the Department of Mines.

MAGNESIUM IN 1915.—The Annual statement issued by the United States Geological Survey, Department of the Interior, on Magnesium in 1915 which is ready for distribution.

MAGNESITE IN 1915.—The annual statement on Magnesite in 1915, published by the United States Geological Survey, Department of the Interior, Washington.

FELDSPAR IN CANADA.—By Hugh S. de Schmid. A book issued by the Canada Department of Mines, Branch, Ottawa, Canada, 1916. No. 401.

TUNGSTEN DEPOSITS OF NORTH-WESTERN INYO COUNTY, CAL.—Bulletin 640-L, issued by the Geological Survey, Washington, D. C.

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Contents for March 15, 1917

EDITORIAL:

The Consolidation of the McGraw and Hill Publishing Companies.....	297
Patriotism in Chemistry.....	297
Interesting Pig Iron Statistics.....	298
Wages in the Hereafter.....	299

READERS' VIEWS AND COMMENTS:

Niagara Falls Power Famine. By F. Austin Ladbury.....	300
Secondary Reactions. By Carl Hering.....	300
Rapid Analysis of Journal Bearing Linings and Babbitt Metal. By Edward J. Koet.....	300
The Recovery of Benzol from Gas. By F. W. Sperr, Jr.....	301
Coming Meetings and Events.....	301
Individual Effort Versus Corporate Effort. By J. R. Finlay.....	301
The Application of Nitro Aromatics in Explosive Industry. By John R. Hardick.....	303
Annual Meeting of American Ceramic Society.....	305
The Western Metallurgical Field.....	306
Consolidation of McGraw Publishing Company, Inc., and the Hill Publishing Company.....	307
Opportunities for Investment of American Capital in Foreign Fields.....	308
Twenty-Fifth Annual Meeting of the New York Section of the American Chemical Society.....	308
The Thiogen Process for Removing Sulphur Fumes.....	309
Actual Work Begun in Course of Chemical Engineering Practice.....	310
Current Density in Copper Refining. By Lawrence Addicks.....	311
The Fixation of Nitrogen as Cyanide.....	315
Salt Manufacture by Solar Evaporation of Salt Water. By Leroy A. Palmer.....	317
The Analysis of Nickel Chromium Alloys. By Emil D. Koepf.....	319
Plastic Cement. By J. B. Barnitt.....	321
Hydroelectric Power and Electrochemistry and Electrometallurgy in France—II. By C. O. Mailloux.....	324
The Cottrell Process for Removing Sulphur Fumes.....	326
Synopsis of Recent Metallurgical and Chemical Literature.....	341
Recent Metallurgical and Chemical Patents.....	343
Notes on Ball-Milling with Special Reference to the Marcy Mill. By F. E. Marcy.....	344
Fumigating Baled Cotton by the Hydrocyanic-Acid Gas Process.....	346
A New Flotation Machine.....	347
Automatic Temperature Control.....	347
BOOK REVIEWS.....	348
PERSONAL.....	350
Current Market Reports—Iron and Steel Market, Non-Ferrous Metal Market, Chemical Market and Price List.....	351
Industrial—Financial, Construction and Operation, and Manufacturers' Notes.....	354

The McGraw-Hill Consolidation

When in 1909 the McGraw-Hill Book Company was founded as the combination of the book departments of the McGraw Publishing Company and of the Hill Publishing Company, this event faintly foreshadowed the much larger merger which has just taken place of the two publishing companies themselves into the McGraw-Hill Publishing Co., Inc. This, the largest technical publishing company in the world, now publishes Metallurgical & Chemical Engineering, Electrical World, Electric Railway Journal, Engineering Record, Electrical Merchandising, and the Contractor (the old McGraw properties) and Engineering & Mining Journal, Engineering News, American Machinist, Power, and Coal Age (the old Hill properties). Since Engineering News and Engineering Record will be consolidated as Engineering News-Record, this list comprises in the whole ten journals and includes the leading journalistic exponents of the professions of the mining, civil, mechanical, electrical and chemical engineers.

The mere bigness of a commercial undertaking often correctly indicates the measure of its success, because in our modern industrial system bigness usually means the availability and efficient use of mechanical machinery and therefore the multiplication of individual human effort by mechanical means to a hitherto unthinkable extent. Whatever can be done along such lines to facilitate the work of a publishing business, will, as a matter of course, be available to the McGraw-Hill Publishing Co., Inc. But the consolidation would mean little if that was all. What is far more important is the consolidation and co-ordination of brains towards the one goal—to make the different journals of the new company live up to their bigger responsibilities for rendering bigger services to their respective engineering fields. That this can only be done by giving each journal fullest freedom for developing and expressing its own individuality, no one understands better than the creator of the new company, Mr. James H. McGraw.

Patriotism in Chemistry

Things are looking pretty dark. We are living over a volcano and now with the threat of war imminent, patriotic citizens will have some earnest thinking to do before the present storm of passion is over. It will take not only thinking but action, and if we are to come out of our sea of troubles without further disgrace, the action must be unselfish all around. We must stand by the President without thought of party or politics and we must be ready to serve with hearts and heads and hands and fortunes.

We should address ourselves to thoughts of order immediately, so that chaos may be overcome. No mat-

ter how deficient the organization of our government may be, this is not the time to criticize; it is the time to help. The first requirement is chemical and metallurgical organization. This means far more than meetings and resolutions. Among other things it means that chemists who can do productive work in making munitions should be restrained from enlisting to serve with the colors. It is patriotism turned up-side-down for a young man who is familiar, for instance, with nitration processes to march behind the band. The place where he can serve his country most efficiently is right in the works and in the laboratory. We do not mean by this that every drug clerk should be freed from the obligation to go to the front. We mean that research and works chemists and chemical engineers are needed more keenly to-day than ever before to prove themselves competent within their professions for their country's sake. We urge upon every chemical society to get into closer touch with its members to the end that it may be a unit of aid. We cannot organize the government but we can organize the production of what the government needs.

Suppose, as seems likely, the government should take over a number of large plants. Then the only patriotic thing to do is to turn each one over as a producing unit, keyed up to its highest efficiency. The failure to provide that it shall produce its best and its maximum under federal control, would be rank disloyalty.

There is no telling what certain senators and congressmen and government officials will do. It seems useless to guess. But hopeless, dull-eyed, adnoidic stupidity will surely show itself on every hand, and this we must meet with unlimited patience and forbearance. It will be almost unendurable, nevertheless it must not only be endured but met in such a manner as to cause the least loss or friction—and this means also the least offense. The chemists of the United States have suddenly become, in large measure, the trustees of her safety. Let us not fail.

Interesting Pig Iron Statistics

For the first time since 1906, the blast furnace industry had in 1916 an opportunity to operate up to the physical limit. Unfortunately the physical limits included a limitation by the railroads, in that toward the close of the year the furnaces were not fully supplied with coke. The actual production of pig iron, as officially reported, was 39,434,797 tons, including 5323 tons of cold blast charcoal iron and 367,088 tons of warm blast charcoal iron, included that made with charcoal and electricity. Three new furnaces were blown in during the year, two River furnaces of Corriگان, McKinney & Company, May 13 and Dec. 30, respectively, Cambria Steel No. 9 in June, and the United Furnace Company's stack at Canton, Ohio, in November. Thus, although the furnaces lost possibly a quarter million tons of production in the last two months of the year through shortage of coke, the actual capacity of the blast furnaces at the beginning of this year was easily 40,000,000 tons per annum.

As noted, 1906 had been the last year of full production with the available capacity, and the output in that year was 25,807,191 tons, last year's output showing an increase of 56 per cent. The production in the decade ended with 1916 was 271,842,307 tons. There is every reason to believe that the total pig iron production in the United States in all the time prior to the past decade did not exceed 325,000,000 tons, from which it appears that 45.6 per cent of all our pig iron has been made in the past ten years, a very interesting fact, particularly when it is recalled that four of those years were distinctly and unequivocally "bad" years. With the new furnaces being built, several of which are expected to be producing within six months, the prospective capacity is at least 45,000,000 tons.

Of the 17,684,087 tons of basic pig iron produced in 1916, 74.2 per cent was delivered molten, against a proportion of 73.7 per cent in 1915. The production of Bessemer and low phosphorus iron in 1916 was 14,422,457 tons, of which 68.2 per cent was delivered molten, against a proportion of 70.9 per cent in 1915. However, the practice at steel works was probably not materially changed, as the merchant production increased from 871,730 tons in 1915 to 1,976,863 tons in 1916. Nearly all of this was necessarily cast, and indeed a very large tonnage was exported in 1916. The total amount of molten Bessemer and basic iron delivered was 23,082,373 tons, of which a small portion, perhaps a quarter million tons, was delivered molten for the manufacture of ingot molds. The remainder would account for the production of about 30,000,000 tons of ingots, out of a total of somewhat more than 40,000,000 tons produced in the year. The statistics are not yet available.

An interesting fact in connection with the pig iron market of the past few months is that while the total production of pig iron increased by 1 per cent the production of foundry iron decreased by 20 per cent. In common parlance too many men were working the same side of the street. The expectation was that on account of the extreme activity in the steel industry the demand would be for basic rather than foundry iron. The result of men's devices is that foundry iron is selling for at least \$2 a ton more in eastern Pennsylvania, and at least \$5 a ton more in the valleys, than basic iron.

There was evidently a remarkable revival in the production of Bessemer steel in 1916. The record production occurred in 1906, with 12,275,830 tons of ingots and castings. From 1907 to 1915, inclusive, production averaged 7,200,000 tons, and the Bessemer steel industry seemed clearly decadent. The 1916 production of Bessemer pig iron, however, was 14,422,457 tons, establishing a new record by passing the 1906 record of 13,840,518 tons. Making allowance for the fact that a few hundred thousand tons of the reported output was really low-phosphorus iron, and the further fact that there were exports of perhaps a quarter million tons or more of Bessemer iron in 1916, it would still appear that the production of Bessemer steel closely approached the record of ten years earlier, one that it

had been thought would stand unchallenged. Two Bessemer plants, Duquesne and Homestead, have been abandoned since 1906, while no new ones have been built, a partial exception being that the Youngstown Sheet & Tube Company's Bessemer plant did not start operating until August, 1906. Some capacity has been diverted to the prosecution of the duplex process. As two Bessemer steel plants are now being built, by the National Tube Company and the Mark Manufacturing Company, both in the Chicago district, the production in future is likely to pass the old mark by a wide margin, provided demand for steel is such as to cause all steel productive capacity to be active. In lean years makers having both processes elect to use the open-hearth. In good years they endeavor to secure a premium in the market for open-hearth.

Wages in the Hereafter

At the time of the Napoleonic wars, Lord Wellington, who besides being a man of action was something of a philosopher, said about as follows: "No one can underestimate the unsettling effect of this war on commerce, and on the way men think and act." We think that this remark is as true in the present as it was one hundred years ago. It bears on many things and with special emphasis on the labor situation both now and in the future. What has occurred with regard to labor is so well known as hardly to need repeating. The influx of "war orders" both for raw and finished military material has so stimulated business that the profits on and the prices of all commodities have been raised to abnormal figures. Most metal prices have been at one time many times those of normal times. Demand has exceeded supply. In short it has been "a seller's market." Labor was the last commodity to rise as always happens in a period of inflation, but has recently risen proportionately to the increase in the cost of commodities. Salaries have risen also somewhat and employment has been general. In the chemical industry, young chemists graduating from college or technical school are receiving some \$200 a month. It was for them "a sellers' market" and they were not loath to take full advantage of their position.

The thought has been frequently expressed in engineering and business circles whether or no this is not a bad thing for the young men. In the first place, these men are not yet really valuable, for their experience in business and engineering is distinctly theoretical. Especially are they liable to be weak in their conduct toward other men. They may understand all about cement and concrete but not be able to tell how concrete should be mixed as well as an Italian laborer. Much less do they generally understand how to mix with men. There is no school like experience for either wise man or fool, and these boys have had no experience. As a general rule, earning high pay is a dangerous thing for young men, for their youthful energy is easily liable to pass into channels of conceit and egotism. In the case of the naturally far-sighted ones, however, they will gain a clear view of the facts of the case and be-

come more modest and learn how to stand prosperity. We have the testimony of a philosopher as to why the human equation proceeds in exactly the opposite way to the normal and expected way, for Herbert Spencer shows how a beautiful girl may be spoiled by attention and become vain, or, on the other hand, how she may see the insincerity of the flatterers and so become modest and unaffected, vanity being seen and realized.

Hard times, we know, will come. Retrenchment and unemployment will come and then the weeds will be eradicated. As to when and how they will come no one can say, since in abnormal times "one man's guess is as good as another." Surely no prosperity founded on destruction can continue long, and prior to the inevitable subsequent period of re-construction and regeneration there will be a period of liquidation and retrenchment. We will now leave these high-priced young puppies with the hope that they may all become prize-winning bench dogs.

In the period of reform there will be several marked general tendencies. The first is the tendency for the rates of wages to lag behind the prices of commodities in a falling market. High wages will be paid to those men that are kept, but the numbers of men employed will be far less. There will be seen on the streets many anxious and drawn faces of men seeking a job. Now, high wages to efficient men may mean a reduction of costs to meet the falling sales prices, but only to a certain extent. In the next twelve months we shall see society's chronic ailment, the H. C. of L., in an acute form, and its relation to wages is a direct one.

Necessity is the mother of invention, and there will be manifest that "inspiration" and that "perspiration" that Edison says when properly mixed are equivalent to genius. Low margins of prices means brains at work. New processes and new machinery will be used. These processes must use cheaper raw materials, less labor, need less repairs, make more by-products and produce higher-grade materials out of low-priced raw material, with a low capital cost. Interest rates will be dear and new processes must be big earners. Economy and efficiency will be the order of the day. Intelligence and industry will be pass-word of the night. In short, there will be a change, hard as it is to realize it to-day. Incidentally, the application of paternalistic ways will become even more marked than it is to-day and in the future increased number of labor disputes, we will see resulting a paternalism in government and business.

In surveying rather briefly and perhaps somewhat hazily the question of labor rates in the next period of liquidation we are struck forcibly with the thought that a very active and pleasant future awaits members of that class of society who read "Metallurgical and Chemical Engineering." Metals and chemicals are now needed for destruction; they will be needed more in the future for construction. Men will be lacking to do all the work. Brains will be then at a premium in the metal and chemical industry. But just now we can imagine each of our readers quite properly bowing to our argument.

Readers' Views and Comments

Niagara Falls Power Famine

To the Editor of Metallurgical & Chemical Engineering

SIR:—Though Mr. McA. Johnson's, "Fundamental Psychology of the Situation" is theoretically sound, he starts from an incorrect hypothesis and concludes with a futile suggestion.

In the first place it is not correct that if "the Falls, all or in large part, were used for power," there would be only factory buildings to see. It is an engineering and economic impossibility to utilize much more than half the available flow for power purposes. It so happens that that portion of the water which could not be so used is about what would be necessary, if properly diverted and distributed, to maintain a spectacle approximately equivalent to that which we have to-day; and the diversion of the remainder for power purposes would put an end to that steady and rapid erosion at the peak of the Horseshoe Falls which is resulting in an increasing concentration of the flow at this one point to the great detriment of the spectacle. It comes to this that if the matter is properly handled there will continue to be "power for the electrochemical industries and scenery for the bridal couples"; otherwise there will in the course of time be neither.

Mr. Johnson's suggestion, in the second place, takes no account of the unfortunate fact that "the people" do not eat ferrosilicon and do not wear carborundum and are therefore apt to be a little obtuse when the "beauties of electrochemistry" are exhibited in their naked form. The only educative policy which is of the least use is publicity in a popular form properly designed to demonstrate the indispensability of electrochemical products to every-day life, to general industry, to preparedness and so on; a task much greater in magnitude than that suggested by Mr. Johnson, but also, as experience is happily beginning to indicate, not entirely ineffective.

As regards taxation of water power, this is a crime against conservation. Water power is used, not because it is water power, but because it is cheap. Every tax tends to limit the extent of its utilization and to substitute the utilization of those non-replenishable resources, the natural fuels.

Niagara Falls, N. Y.

F. AUSTIN LIDBURY.

Secondary Reactions

To the Editor of Metallurgical & Chemical Engineering

SIR:—In explaining some electrolytic reactions there seems to be a decided difference of opinion as to whether they are all primary, or whether some of them are secondary. In the writer's opinion a primary reaction is one which is produced directly by the current, while a secondary reaction is one which is produced by the chemical inter-reactions of the compounds or elements produced or set free by the electrolysis. This is believed to be the intent of the meaning of those terms. It is, however, not always easy to distinguish definitely between the two.

The writer believes no one will contest his statement that any reactions which do not take place exactly simultaneously with the passage of the current and in proportion to it, as also those that continue after the current ceases, are unquestionably secondary. This eliminates some reactions from discussion, but it is not a

definition applying to all, as there may still be other kinds of secondary reactions.

To say that the current separates sulphuric acid into H_2 and SO_2 , and that the reaction of the latter radical at the platinum anode combining with H_2 from the water and setting free oxygen, is a secondary reaction, would probably not find general acceptance, as SO_2 does not exist by itself as a molecule, and it would hardly seem rational to say that the electrolytic process was completed until two new, complete, chemical compounds, or free elements, had been produced.

There are probably but few if any chemical changes which do not involve some exchange or transformation of energy, they being either exothermic or endothermic. Hence it seems to the writer that the seat of this energy forms perhaps the best method of distinguishing between primary and secondary reactions, a primary reaction being the one whose energy appears in the electric circuit, while a secondary reaction is one the energy of which does not appear in the electric circuit. If, for instance, zinc is deposited on to a platinum cathode the energy of its reduction must, of course, come from the electric circuit, while when it is subsequently or even simultaneously dissolved by the acid present the energy involved in dissolving it surely does not appear in the electric circuit, and is therefore secondary.

A discussion of this subject of the definite distinction between primary and secondary reactions in this journal might lead to some interesting and useful results.

CARL HERING.

Philadelphia, Pa.

Rapid Analysis of Journal Bearing Linings and Babbitt Metal

To the Editor of Metallurgical & Chemical Engineering

SIR:—The chemist oftentimes is called upon for a rapid analysis of journal bearing linings and babbitt metal, and unless he has had considerable experience in the determination of lead, tin, and antimony in the presence of one another, the analysis becomes somewhat difficult.

The following simplified methods of analysis have been found to be very rapid and accurate. They are modified and simplified compilations of various methods now in use.

METHODS OF ANALYSIS OF JOURNAL BEARING LININGS AND BABBITT METAL

Method for Tin.—Dissolve 1 gram of filings in 20 c.c. of concentrated hydrochloric acid, adding a few drops of nitric acid from time to time until fully dissolved. Concentrate about one-half, add 10 c.c. more of hydrochloric acid and again boil until all nitric acid has been driven off. Add 20 c.c. of concentrated hydrochloric acid, 100 c.c. of water and 2 steel nails. Boil for 25 minutes, cool rapidly with exclusion of air as much as possible, and filter into a 400 c.c. Erlenmeyer flask, wash with cold water, adding 25 c.c. of hydrochloric acid from time to time to the filtrate. Dilute to about 200 c.c. and titrate with N/10 iodine solution using starch as an indicator.

Standardization of N/10 iodine: 12.65 grams I per liter and 30 grams KI; 1 c.c. = 0.01265 gram I approximately; 0.5 gram C.P. tin is dissolved in 20 c.c. of hydrochloric acid, using as little nitric acid as possible. Run almost to dryness and add 10 c.c. concen-

trated hydrochloric acid. Repeat and take up with 10 c.c. of hydrochloric acid and make up to 500 c.c. in a graduated flask.

Use 100 c.c. of this solution to standardize the iodine, adding 25 c.c. hydrochloric acid, two nails, and proceeding exactly as in the above.

Method for Antimony.—One gram of the filings is transferred to a 400 c.c. Erlenmeyer flask; 15 c.c. of concentrated sulphuric acid and 2 grams K_2SO_4 are added and the flask heated on the hot plate until all is dissolved. This is generally accomplished in about thirty minutes from the time fumes of sulphur trioxide begin to be given off. The residue should be white. Seventy-five c.c. of cold water is added after the contents of the flask are thoroughly cooled; 10 c.c. of hydrochloric acid are now added and the solution boiled for exactly twelve minutes. It is then removed from the hot plate and made up to about 200 c.c. with cold water and titrated with standard N/10 potassium permanganate. Standardization of the N/10 potassium permanganate is carried out as follows: To 0.2 gram of C.P. antimony add 15 c.c. concentrated sulphuric acid, heat on a hot plate until solution is complete, cool thoroughly, add 75 c.c. water and 10 c.c. hydrochloric acid and boil for twelve minutes. Make up to about 200 c.c. with cold water and titrate against the permanganate. From this can be calculated the exact strength of the permanganate in terms of antimony.

Method for Lead.—After the antimony has been titrated, boil for about ten minutes in order to remove all the permanganate, cool and filter off the lead sulphate, washing with 1 to 10 sulphuric acid. Dissolve the precipitate with ammonium acetate and acetic acid and precipitate the lead with a 10 per cent solution of potassium bichromate. Let stand on a steam bath until the precipitate is all settled. Filter on a tared Gooch crucible.

Wash with 3 per cent acetic acid. Dry in the air oven at 100 deg. C. and weigh as lead chromate. Calculate the lead.

Notes.—Determine Sb and Sn on same sample by first titrating Sb, then reducing with iron nails. Filter and titrate Sn.

For small amounts of copper, also Sb, Sn and Pb, a 1 or 2 gram sample is dissolved in aqua regia. After solution add tartaric acid (10 grams) and neutralize with 20 per cent NaOH. Then add 20 c.c. alkaline tartrate, heat and add 30 c.c. sugar. Proceed with CuO in regular way.

For Lead in Large Amounts.—A 0.2000-gram sample is dissolved in HCl with addition of $KClO_4$. Cool, add 10 c.c. H_2SO_4 conc. and evaporate to fumes of SO_3 . Weigh $PbSO_4$, and to 100 per cent $PbSO_4$ add 0.20 per cent for solubility.

EDWARD J. KOET.

Goodyear Tire & Rubber Co.,
Akron, Ohio.

The Recovery of Benzol from Gas

To the Editor of Metallurgical & Chemical Engineering

SIR:—In Table II of my paper on the Recovery of Benzol from Gas (page 137 of your issue of Feb. 1, 1917) the following minor corrections should be made:

Vapor pressure of toluene at 30 deg. C. should read 37.46 instead of 37.45.

Kg. per cbm. vapor (0 deg. C. 750 mm.) should read kg. per cbm. vapor (0 deg. C. 760 mm.).

Reference 21 should read "Calculated from 10, 17, 19, 20, 27, 28, 2, 3, 5, 8," instead of "Calculated from 10, 18, 19, 20, 27, 28, 2, 3, 5, 8."

F. W. SPERR, JR.

Pittsburgh, Pa.

Coming Meetings and Events

American Chemical Society, spring meeting, Kansas City, Mo., week of April 9, 1917.

American Electrochemical Society, spring meeting, Detroit, Mich., May 2-5, 1917.

American Iron and Steel Institute, New York, May 25-26, 1917.

American Society for Testing Materials, Atlantic City, June 26-30, 1917.

Third National Exposition of Chemical Industries, Grand Central Palace, New York, week of Sept. 24, 1917.

American Institute of Metals and Foundrymen's Association, Boston, week of Sept. 24, 1917.

American Electrochemical Society, autumn meeting, Pittsburgh, Oct. 3-6, 1917.

American Institute of Mining Engineers, annual meeting, St. Louis, Oct. 8-13, 1917.

Individual Effort Versus Corporate Effort*

By J. R. Finlay

The underlying impulse of modern life is the use of mechanical energy to multiply human energy; this brings with it an enormous increase of co-operative or corporate effort; this is changing profoundly our habits of living and making a living, as shown by the growth of immense cities and the employment of large armies of men by single industrial enterprises; it is also affecting our ideas of government, of polity, and of social intercourse.

Now this society has made a great point in giving a medal each year to signalize its appreciation of some individual who has distinguished himself by advancing the arts connected with mining. I expected during the year 1916 to take part, as president of this society, in some ceremonies appropriate to giving such a medal to Professor James F. Kemp for distinguished services in the science of economic geology. Tonight we shall announce the award of the medal to Mr. E. P. Mathewson for distinguishing himself in the art of metallurgy. It would appear from this that the individual still counts for something in our opinion. It also appears that the substitution of corporate effort for individual effort does not destroy the individual: for otherwise we should be giving our medals to corporations.

Now the subject is not so easily dismissed. We have traveled a long way in the direction of substituting the factory for the handicraft. An unskilled boy with a machine, for instance, may turn out as many horse-shoe nails as a hundred blacksmiths. Are we not, after all, bringing forward only an occasional man who can perfect a machine and by the same action condemning to a life of hopeless automatism the thousands of men who are to run that machine? This is the view that millions of people have taken, or think they have taken, and who in taking it look with displeasure upon the growth of modern industrialism.

I have been revolving this question in my mind for the past two years and it seems to me I am warranted in expressing the belief that our modern life does not tend to destroy individuality. In fact, the question of human quality seems to be more and more important. I think we mining people have been passing through a period during which we have laid too much stress on natural factors and on technical processes. We are working out of that. Our more experienced men now realize fully and enthusiastically, not as a poetic fancy, but as a practical fact, that the "highest study of man-

*Presidential address before the Mining and Metallurgical Society of America. Very slightly abstracted.

kind is man." To develop a good human specimen, a man or a woman with a balance of good qualities, rises far above any technical subject. The formidable animal is not the product of any system. He is not made by technical training. Technical training is only a tool that he uses. Gold is of no value in itself; its sole value lies in a certain appeal it has made to the human imagination. We have often deluded ourselves into thinking that we are working for things, when in reality we are working to satisfy human wants. A house is of no value unless somebody lives in it, clothes are of no value unless people wear them. We don't dig diamonds for diamonds; we dig to ornament our women!

During the past year or two I have visited and studied in one way or another a good many industrial concerns and I have come to the conclusion that corporate effort is not a substitute for individual effort, but is founded upon individual effort; it can be no better than the materials it is made of. A business may run along all right with a poor or mediocre personnel, just as a house may stand all right and look all right if built of poor materials, but neither can stand a critical test.

The question is, does the training and discipline imposed upon men who must become cogs in great industrial organizations rob them of individual initiative? This is a question really as to the nature of discipline.

On this point, one of the best things I have ever seen was a speech of Mr. Percy Haughton, chief coach of the Harvard football team. After describing how the problem of winning a game was one of team-play by which eleven men might act as one, Mr. Haughton says that to obtain this result careful discipline is necessary, and this discipline can be divided into three elements—physical, moral and mental. Physical training is a mere matter of proper exercise for the muscles and proper care of the body; moral training the preparation of a willingness to do the right thing in the common interest. Mental discipline really includes the others, but relates especially to the development of those perceptions and discriminations which guide an intelligent man. These have to be trained with especial care. The football player is taught to do the obvious and recurrent acts of the game and to obey orders relating to them with the greatest possible precision and dispatch, as nearly as possible without thinking that is, automatically. Does this destroy initiative? No! is Mr. Haughton's emphatic answer, quite the contrary. It is only the most intelligent who can acquire in the highest degree the power to respond to suggestion and to distinguish between an act of routine and a situation requiring initiative. By this test many a fine physical specimen is driven from the team by apparently inferior men. It has been proved times without number that eleven powerful muscular systems operating incoherently are no match for eleven men of average physique whose actions are intelligently co-ordinated. It is not a question merely of willingness to obey orders; it is more apt to be a question of ability to execute orders. When these men have laid a broad foundation of skill in performing those acts which can be formalized, that is, which are so recurrent that they can be reduced to routine, they are able to recognize the situation which is not routine. In other words he is then able to use initiative intelligently, and not till then. "Proper discipline," said a German friend of mine who expressed himself somewhat like an Irishman, "destroys initiative only in those who have no initiative to destroy."

It is clear to me that the same principles apply to industry as to a football team or to an army. The effective employee decidedly must have other qualities besides submissiveness. The effective manager will never forget this. He recognizes that orders can be obeyed

effectively and promptly only by intelligent men who can see value in swift and sure performance. Such men show ability in discarding the stupid inutilities of custom and substituting the ordered performance of necessary acts. Many of us imagine that we spend all our time exercising initiative, that we do things through a constant choice of the best thing to do. Nothing is farther from the truth. We spend most of our time, nearly all of it, doing things automatically. We eat and dress after manners developed by long custom. Our own people are only just learning to make a regular custom of washing. We all believe we are intelligent men, capable of initiative, but which of us would dress in Chinese costume and go out on the streets without excitement? We know perfectly well that Chinese clothes are just as good as our own in every respect; why not wear them? Simply because we are accustomed to dress in a certain way, automatically adjusting our minds to follow a system that nobody questions, limiting our liberty of selection to a very narrow range; the wearing of a totally different style requires a new adjustment. We are not interested in clothes and have no initiative about matters of dress. It is only occasionally that we perform an act on our own independent judgment. When you come to think of it, what chance would a man have of selecting the best possible mode of dressing the first time he thought of the subject?

The sound principle of corporate efficiency is expressed by the old saying that "two heads are better than one." How much truer that a thousand or ten thousand heads are better than one? That co-ordinated use of brains results in enormous power and explains the "industrial miracles" that we talk of. It is the true and only explanation of real efficiency.

Any one who thinks this is merely an academic conclusion deceives himself, for the direction of corporate effort is the supreme practical problem of our country and time. It is true, I suppose, that many people go through their business lives successfully without giving any profound attention to the principles which actuate them, but many such would be utterly surprised to find out how far they fall short of good management. Broadly speaking, we find two conceptions of corporate management, the first, and perhaps the most common, being that the main body of employees has no business except to obey and that their activities can all be regulated by orders given in detail by a few select individuals at the top. The watchword of discipline, according to this scheme, is "obey orders if you break owners." The motive is a superficial worship of detail for its own sake. Devotees of detail always find that their employees are not prepared to understand their plans in all their exactitude and promptly jump to the conclusion that the average man cannot be trusted to do anything except under constant supervision, and that the best and highest service the great mass of men can render is that of unquestioning and unthinking subservience. Their idea of organization is the relationship of master and slave. The only ability they wish to recognize is their own ability.

This is poor management. The history of nations proves that! There is no strength in a body politic consisting of many slaves and a few masters. In industry, this theory of management can never produce anything above mediocrity and always ranges down from that to sheer failure.

Real organization depends on what some English philosopher has called "enlightened selfishness." By this plan a leader represents the common purpose, say, of the hundred best men to be had for a given work, and has their backing. That is very different from having a hundred men on whom he merely imposes his will. I suppose people work generally either for money

or for distinction. Each man has a selfish desire to obtain one or the other. Unenlightened selfishness leads a man to wish to be prominent by preventing others from doing things in his stead, or to be rich merely by comparison with others who have nothing. Enlightened selfishness prefers to get success out of the success of others, recognizing that one might be richer by letting others get rich and more distinguished if others help him do things and thereby gain distinction, too. I have seen examples of both attitudes, and have been astonished to find that men at the head of companies wanted no better reason for doing a thing except to have their way and who really cared for no result from the efforts of large numbers of people except to maintain their own position. A man with enough force of will often is able to do this for a long time, but he is weighted with a barren purpose which leads nowhere. Such a man will deliberately choose subordinates of inferior caliber merely because he is sure to dominate them. You all know that it is a commonplace that you mustn't get too good a man for a job! It is dangerous to get too many good men around for fear some one will turn up better than yourself and get your place!

Well, fear of good men is a sure sign of mediocrity or worse. The real leader thinks of nothing so much as to get the very best men that can be had. He is on the lookout for them everywhere, especially among his own employees, realizing fully that work is not done by muscle but by brains and that the more he makes use of the mentality and initiative of all the men the greater his output will be.

How is this done? By interesting the men, appealing to the self-interest and making it worth their while to work for results. I can give you a hint of how it is done by imagining a case; no, not imagining, for it happens every day. Suppose a man is driving a drift in a mine and suppose you approach him with this kind of a proposition:

"You are driving this drift for \$10 a foot; that's what it costs. We are well enough satisfied with it, but how would it strike you to see if you could figure out some way of doing it cheaper? If you do it for less than \$10 we will split the profit with you."

The miner goes home and tells his wife about it. "Don't do that, John," she will say, "that's only a scheme to get more work out of you. You are doing enough now."

Our man thinks that's about it, and decides to refuse the offer. The incident is ended apparently.

But likely as not it is not ended! True, the man has not done anything, but perhaps he has started thinking about his work, instead of politely going through the motions while really thinking about something else. He will not respond to your suggestion, you may be sure, if he suspects you are a designing rascal intending to exploit him; he must have confidence in you. Given that, our man may think up something worth while and, having done so, will overcome the objections of his wife or anybody else and undertake to put his idea in practice. Even if he does not, the interest he takes in the subject puts things forward because it helps stimulate interest on the part of others.

This kind of thing is not technical, it is human leadership. Your man who is able to do this is no more to be turned out of a school by the force of a curriculum than is a poet. That does not argue against education, for even a poet is no better for being an ignoramus; it merely argues for education of the right sort and against trying to educate square pegs to fit round holes.

You hear a great deal about labor troubles. Nine-tenths of them are caused by poor leadership. A strike may be caused by one of two things: either the conditions are so bad, or so irksome, that it inevitably occurs

to the men to rebel against them; or some agitator persuades them to rebel. How does the agitator do that? Simply by interesting them more than their employer does. Perhaps life is merely dull and he offers a prospect of excitement and change. If an agitator can make such a proposition stick against the apparent self-interest of the men, I take it that he displays ability and that the employer ought to change places with him. Your real leader will not be satisfied merely to call the agitator an interloping blatherskite behind the men's backs; if that is true he will make them feel it. Your conspicuously successful concerns don't have strikes; there is no money in them for anybody. The Standard Oil Co., berated by outsiders for forty years, always held the loyalty of its employees, and although those men were in plants all over the world there was never a strike until a few months ago. The men who founded and built up that concern were great men, too big to be supplanted by mere agitators, or to try to ignore the genuine interests of their employees. If you will notice the cases where strikes have occurred in successful concerns you will find that the managers of plants where they do occur usually lose their jobs before the thing is finally settled. One of the great forces in human nature is the sporting instinct; man wants to fight somebody and beat him. The battle of industry is just as savage as any other battle and your true leader knows it. It is a mighty poor human atmosphere where the men feel they have nothing better to fight than the clock. They don't stand that long. If they get to killing time that is only a step toward killing men.

The Application of Nitro Aromatics in Explosive Industry

By John R. Mardick

The basis of every kind of explosive made in this country from high-power gelatine dynamite down to low-grade permissible explosives contains nitroglycerine. This is specially true in the case of blasting explosives, or, in fact, all the explosives made for commercial purposes; for instance, explosives used for shattering rock, tearing dirt, and mining coal contain nitroglycerine.

As a result of the large demand for glycerine in the explosive industry the price of this commodity has gone from 12 cents per pound a few years ago up to 60 cents per pound at the present time. There are no indications that these prices would be any less after this war is over. The reason for this high price of glycerine is that the supply has not increased with the demand. As a matter of fact, the fat stock which is the only principal source of glycerine remains either stationary or, if anything at all, it has a tendency to decline.

The glycerine situation is similar to that of hide and leather. There is more demand for hide and leather than the supply of the world can take care of. This situation in hide and leather has given a new start for artificial leather. In the same way as the price of glycerine increases, explosives containing nitroglycerine will command a higher price than ever before.

It has been said that necessity is the mother of invention. The high price of Italian sulphur compelled the sulphuric acid manufacturers to use pyrites. So if we must have explosives we may resort to other raw materials to compete with dynamite made from a high-price glycerine. The price of modern commercial blasting explosives has doubled in the last few years, and there are no indications that with glycerine even at 30 cents per pound the manufacturers will be able to offer low-price explosives, say at 10 or 11 cents per pound.

Fortunately, there are other cheap raw materials from which powerful commercial explosives can be made. I refer to certain nitro-aromatic bodies which are made in this country at present for military purposes, and which have not been compounded as yet into blasting explosives. The sources of aromatic bodies are almost inexhaustible, and the situation is likely to remain so in spite of the fact that large quantities of coal-tar oils will be applied in dyestuff industries in the very near future. To be more specific, toluol, phenol and other similar derivatives from coal tar would be a drag on the market after the war is over. It is not unlikely that toluol will drop to as low a price as 30 cents a gallon. Synthetic phenol will disappear from the market altogether, and the natural carboic acid will probably bring less than 10 cents a pound. It is easy to see that with such cheap raw materials on hand the problem of manufacturing high explosives at reasonable prices will be readily solved.

It must be admitted that there are some difficulties which must be overcome before it will be possible to engage in the manufacture of commercial explosives having for their base nitro-aromatic bodies such as trinitro-toluol and picric acid. The greatest obstacle to success in this line would be the natural prejudice of the explosive manufacturers themselves against the use and application of aromatic compounds. There are explosive manufacturers in the trade who think that the only successful blasting explosives for all-around purposes are dynamites and those explosives having nitroglycerine as a base. They say that other explosives starting from the aromatic series are either too dangerous or not sensitive enough for commercial uses. They forget the fact that the manufacture and the use of N.G. as explosive was strongly forbidden for some time, until Alfred Nobel overcame all the difficulties, controlled the manufacturing process and the dangers of N.G., and thus laid the foundation of his immense fortune.

No serious efforts have been made in this country to make explosives containing other than N.G. True, there have been spasmodic attempts here and there by amateurs, but they had neither the technical organization nor the necessary capital to push the matter through. With the first difficulty their enthusiasm died away. At the present time there are two firms in this country who make blasting explosives which do not contain N.G. One has nitrostarch for its base and the other chlorates. However, the volume of their business has not assumed such large proportions as to make them a large factor in the explosive business. Seven firms, large and small, make only N.G. explosives and control the entire U. S. market.

Before the war all the principal countries in Europe, including Germany, England, France, Austria, Italy, Belgium and Russia, were making large quantities of explosives from nitro-aromatic compounds, which were known as *safety explosives*, and were very successfully used in all kinds of blasting, mining and quarrying work. Some of these explosives correspond to our *permissible* explosives used in coal mining, where N.G. explosives were excluded on account of its pulverizing effect on coal. It is a fact that nitro-aromatic explosives while somewhat slow in velocity have a better shattering action than N.G. explosives, and are especially suitable in quarrying and coal mining.

It seems to me that this is an opportune time for T.N.T. and picric acid manufacturers to look into this matter from the business and manufacturing standpoints. They have their plants all built up, they have the capital, and after paying for land, machinery, etc., undoubtedly they have made some money. On the

other hand, probably, they have got the last of their war orders. What are they going to do with their plants? Some say, "What do I care? I have made some money over all the expenses and can afford to dismantle the plant and sell the land." Others may continue to make a limited quantity of secondary chemicals for dyestuff manufacture, and thus keep up a small business. But there are other important uses for their investment, as we shall see from the following.

According to the report of U. S. Bureau of Mines for the calendar year 1915, there were manufactured in this country:

High explosives (N. G.).....	117,907 tons
Permissible explosives (N. G. and ammonia).....	13,687 tons
Blasting black powder.....	98,860 tons

It may be remarked that N.G. forms the basis of all high explosives while the black powder is made up as usual from nitrate of soda, sulphur and charcoal. The same statistics show that the production of black blasting powder is steadily decreasing from 115,000 tons in 1912 to 98,860 tons in 1915. Evidently permissible explosives are making heavy inroads into the blasting-powder business. This is evident from the fact that the manufacture and use of permissible powders have increased correspondingly with the decrease of black blasting powder.

As we see from these quotations, there are good chances to replace blasting powder by permissible explosives made from aromatic bodies, such as T.N.T. and picric acid, which will meet easily the Government requirements much better than N.G. permissible explosives. In making explosives one must not lose sight of the fact that N.G. contains more than sufficient oxygen for its combustion, while the nitro-aromatic bodies, including T.N.T. and picric acid, are deficient in it. In order to produce a complete combustion it is necessary to add oxygen carriers to the aromatic compounds in the shape of nitrates or chlorates, and thus eliminate as much as possible the formation of dangerous gases like carbon monoxide.

The prospective manufacturers of explosives must allow ample time to proceed carefully and slowly in making scientific combinations. First, they ought to adjust and correct their processes in order to produce the highest possible yield in T.N.T. and picric acid, by sacrificing time for more yield and better quality. As they have no rush war orders to fill they can cut down their expenses commensurate with the highest yield. Then they will be in position to compare the cost of production of N.G. at 235 lb., T.N.T. at 215, and picric acid at 190 as yields for 100 lb. of raw material.

The cost of raw materials may be represented as 30, 8 and 4 cents for glycerine, phenol and toluol respectively. Furthermore, in making exact calculations it is perhaps advisable to assume the price of nitric acid to be 5 cents (100 per cent) and that of sulphuric acid (100 per cent) to be 1 cent per pound.

The manufacturing cost of a 40 per cent explosive in normal conditions may be figured out as follows:

Straight Dynamite	Percentage	Cost per Pound	Cost
Nitroglycerine	40	.20	8.00
Wood pulp	15	.01	.15
Sodium nitrate	44	.0234	.99
Anti acid (carbonate)	1	.01	.01
Labor, power, boxing, etc.			1.15
Cost per pound of straight 40 per cent dynamite.....			10.30

Before the war this 40 per cent explosive was manufactured at 8 cents per pound and sold at 10 to 10½ per pound (wholesale). In the same way the cost of other dynamite explosives known in the trade as low-freezing, ammonia, and gelatine dynamites, may be calculated.

Now compare this cost with the same grade (40 per

cent) of safety explosive made from a nitro-aromatic compound:

	Percentage	Cost per Pound	Cost
Nitro-aromatics	25	10	2.50
Combustibles	10	1	.10
"Dope"	64	3	1.92
Anti Acid	1	1	.01
Labor, power, boxing, etc.	..	..	1.50
Cost per pound of 40 per cent new explosive			6.03

As we see from these figures, the cost of aromatic explosives stands out 6 to 10 against N.G. explosives. In other words, there would be a clear margin of 4 cents in favor of aromatic explosives against the same grade of dynamite. The 40 per cent straight dynamite with a manufacturing cost of 10 cents per pound cannot be sold in normal times at less than 14 cents per pound.

Manufacturing cost	10.30
Overhead expenses, selling	2.00
Net profit	1.70
Selling price of 40 per cent straight dynamite	14.00

It is easy to see that aromatic explosives under the same conditions can easily compete against N.G. explosives.

I have tried to point out very briefly the possibilities and the promising future of nitro-aromatic explosives. It will pay for T.N.T. and picric acid manufacturers to make further investigations along these lines before dismantling their plants. On the supposition that aromatic explosives may secure 25 per cent of the explosive business, there would be a volume of new business amounting to 30,000 tons per year, which at a conservative profit of \$60 per ton will figure out as \$1,800,000 per annum. This certainly is not a negligible business.

Will the T.N.T. and picric acid manufacturers overlook this field of enterprise knocking at their very doors? The proposition from a commercial, economic and hygienic standpoint is a feasible one. They have the capital and the plants to start with. Why not bring together an efficient technical explosive organization and start the ball rolling while there is yet time?

New York City.

Annual Meeting of American Ceramic Society

The annual meeting of the American Ceramic Society was held in New York City Monday, March 5, to Thursday, March 8, with headquarters at the Hotel Astor. The business session was held on Monday morning, followed by the presidential address of LAWRENCE E. BARRINGER of the General Electric Company, Schenectady, N. Y. Sessions for the reading of papers were held at the Astor on Monday afternoon, Tuesday morning and Wednesday morning and afternoon. On Tuesday afternoon a session was held at the Metropolitan Museum, including lectures and an inspection tour. On Thursday an all-day excursion was taken to Perth Amboy, N. J., and vicinity to visit the plants of the Atlantic Terra Cotta Company, Didier-March Company and the Fords Porcelain Works.

A paper on "Humidity: Its Control and Relation to Drying Clay Wares" was read by W. A. DENMEAD of the General Electric Company, Schenectady, N. Y. The subject is an important one, and in discussing the paper President Barringer said that through the study of humidity the General Electric Company has been able to reduce the time of drying from eight to nine weeks to about one week. The Harbison-Walker Refractories Company at Pittsburgh have also greatly reduced the drying time by the study of this subject. He said that the air conditioning manufacturers and engineers are able to furnish apparatus and data on this subject of great value to manufacturers of claywares, and that a

greater appreciation of the subject would be found of great benefit.

A paper on "Making Paving Brick from Blast-Furnace Slag" was read by J. B. SHAW of Alfred, N. Y. Mr. Shaw has recently concluded some very successful tests along new lines. The subject has been investigated by nearly every blast furnace plant, in most cases with negative results. Mr. Shaw placed the amount of slag available as 16,000,000 tons, based on a pig iron output of 33,000,000 tons. Two million thousand paving bricks could be produced from this, and still leave 2,000,000 tons of slag for cement manufacture. In 1915 \$35 per 1000 was paid for the slag bricks which were made. At present it costs blast furnaces on the average 10 cents per ton to dispose of their slag. Mr. Shaw stated that brick can be successfully made at from \$5 to \$7 per 1000. He has visited many blast furnaces in the country and found that nearly all of them had done some work on the subject, which had practically all resulted in failure. In tests made at the Birmingham Slag Company's plant at Birmingham, Ala., he found that by making changes in the slag by adding sand, iron oxide, etc., that various kinds of brick could be successfully made. It was found that the slag must be taken molten just as it comes from the furnace and the modifications made then, as it would not be economical to remelt it. American slags run about 12-14 per cent Al_2O_3 + Fe_2O_3 , while the English slags from which brick are made run 20 per cent and over. Tests were made at the plant of the Bethlehem Steel Company at Sparrows Point, Md., and brick were made from the slag there which were better than the shale brick and equal to the English brick. Efforts were made to obtain patents on the process, but owing to numerous other basic claims this was found to be out of the question. In reply to a question Mr. Shaw said the brick must be annealed out of contact with air or steam. The annealing should be started at almost the softening temperature and held uniform. The brick will not then become brittle. He thinks that any slag can be successfully used.

An interesting illustrated talk on "By-product Coke Oven Construction" was given by R. J. MONTGOMERY of the H. Koppers Company, Pittsburgh, Pa. He said that construction of by-product coke ovens in this country was only limited by the production of high-grade silica brick. For the modern oven 227 different silica shapes and 85 clay shapes are needed. The silica brick manufacturers have so far been slow in taking care of this difficult proposition adequately, and neither they nor the oven builders are satisfied as yet.

Many other interesting papers were read at the meeting, an account of which is reserved for a later issue. One of the features of the last day was Emerson P. Poste's paper on enamel surfaces under the microscope. The whole convention was very well attended and was successful in every respect.

Spring Meeting of American Chemical Society

The spring meeting of the American Chemical Society will be held in Kansas City, Mo., and vicinity from Monday, April 9 to Saturday, April 14. The headquarters will be at the Hotel Muehlebach. A general meeting will be held on Wednesday morning at which addresses will be made by Hon. George H. Edwards, mayor of Kansas City; Dr. Frank Strong, chancellor of University of Kansas and Dr. Julius Stieglitz, president of the A. C. S. A public session will be held on Wednesday afternoon on "Petroleum and Natural Gas," and on Wednesday evening a smoker will be held. The banquet will be held on Thursday evening.

Western Metallurgical Field

Cobalt

Cobalt Alloys with Non-Corrosive Properties.—Bulletin No. 411 of the Canada Department of Mines is Part IV of Researches on Cobalt and Cobalt Alloys, by Dr. HERBERT T. KALMUS and K. B. BLAKE. It is a treatise on non-corrosive alloys containing cobalt and covers 37 pages. The article is profusely illustrated with photomicrographs and curves. It is an elaboration of the same author's paper presented at the last convention of the American Institute of Chemical Engineers (this journal, Jan. 15, p. 82).

The conclusions drawn from preliminary tests were: that additions of nickel or cobalt to American ingot iron proved beneficial as far as non-corrosive properties were concerned with cobalt ranking first. The final conclusions drawn from the work are: that the corrosion in grams per square centimeter per hour of the original surface is a function of the length of exposure. Alloys formed by the small addition of copper, nickel and cobalt (0.25 to 3.0 per cent) to American ingot are more resistant to atmospheric corrosion than the pure iron itself. Alloys made with cobalt (0.25 to 3.0 per cent) from American ingot iron with very little, if any, carbon indicate, that the corrosion is not a simple function of the percentage of cobalt content. Alloys containing 3 per cent cobalt showed a corrosion amounting to 75 per cent of that obtained with alloys containing 0.5 per cent cobalt. Alloys with from 0.25 per cent to 3.0 per cent cobalt and low in carbon show atmospheric corrosion to the extent of 50 to 75 per cent of that of pure American ingot iron. Very little difference in the corrosive action could be observed whether cobalt or nickel was used. The oxide coatings formed during the progress of corrosion on the surfaces of the materials indicated that those formed when cobalt was used were darker in color, denser and more tenacious than those formed by the other alloys. However, though this coating with cobalt had a better appearance, the protective quality was not in favor of cobalt. An addition of copper (0.25 to 0.75 per cent) seemed to reduce the atmospheric corrosion of American ingot iron. The authors are conducting further experiments along these lines which will be published in a later paper.

Flotation

The New Trend in Flotation Practice.—It is worthy of notice, that not all the companies using the flotation process are going to pay back and future royalties to the Minerals Separation, Ltd., without another endeavor to prove, that the process may be used without infringing on the patents of said corporation. The general trend of the newer investigations is along the lines of using more than 1 per cent oil and circulating same in the process. The idea may be explained as follows:

The pulp from the ball mill enters a sludge tank. From this tank the pulp goes to an emulsifier from where it enters the flotation cells. The froth collected in the "spitz" of the cells is filtered through a revolving filter of the Oliver type, from where the partly dried concentrates go to a bin. The water plus oil from the filter press goes back to the sludge tank from where it again enters the system. The tailings from the flotation cells are conducted to Dorr thickeners, where they are partly dewatered; the water plus oil obtained from this operation also is returned to the sludge tank to be re-used in the system. The tails from the thickener go to waste.

The idea as such is very clever. It is the intention of the companies working along these lines always to replace the oil used up and to maintain the flow of oil in

the circuit above 1 per cent of the ore treated. Unconsciously, one might say, is this scheme "fool-proof"? Would it be possible to show that the oil used during the operation, allowing a certain percentage for mechanical loss, which is actually doing the work is still less than 1 per cent.

The Flotation of Tungsten Ores.—Some experimental work has been done on the flotation of ferberite ores of the Nederland District of Colorado. The results showed that these tungsten ores could be concentrated by means of flotation as far as laboratory tests were concerned. On the other hand, practical tests have shown that the flotation of the tungsten values from these ores was uneconomical. The reasons given for the latter statement are as follows: The mill run as a rule is not uniform enough as regards WO₃ content. The presence of iron in some of the ores destroys the action of the oil mixtures used. And finally the presence of "horn rock," a jasper wherein the coloring matter is tungsten instead of iron, is detrimental to the action of the oil.

The Flotation of Molybdenite.—In the Summary Report of the Canadian Department of Mines for the year 1915, which has recently appeared, several pages are taken up with results and other data regarding the flotation of molybdenite. The tests made were laboratory tests and in general were conducted as follows: the ore was crushed in jaw crushers to about 1 in. size. This material was then elevated to an ore bin from where it passed through rolls set at ½ in. From the rolls the ore passed to Ferraris screens fitted with ¾ and 1/16 in. openings. On these screens the flaky material was picked out and kept separately. The final size ready for the flotation ranged between 16 and 20 mesh. This product was then fed to a Wood flotation machine and floated with water. As the tests were run on a comparatively small scale the results obtained indicated large percentage losses, which it is believed would not be the case if practised on a large scale. The following general conclusions were reached: Crushing in stages is advisable. The fines should not be rejected, as this practice would involve a considerable loss. Hand sorting should be resorted to, as a large amount of flake can be obtained in this way. After hand picking the ore should be crushed from 16 to 20 mesh and sized for flotation by water. The combined hand picking and flotation should give a recovery of 80 to 85 per cent molybdenite in practice.

Company Reports

The Twenty-third Annual Report of the Portland Gold Mining Co.—During the past year 394,788 crude tons of ore and waste were mined and handled by the company operations. After sorting, this yielded 63,457 tons of shipping ore which gave a gross return of \$1,540,462.49 or \$24,275 per ton. The ore milled at the Victor plant showed a decrease in value of 39 cents per ton as compared with last year, or 13 per cent for the year. The gross value of ore mined and shipped was \$2,236,842.46. The gross values recovered at the Victor mills amounted to \$612,576.89. The net cost of mining and milling amounted to \$2,102,715.92. The gross profit from operation is therefore \$746,703.43. To this latter figure are added \$22,106.41 for revenues from all other sources, which bring the net profits of the company for the past year as far as mining and milling operations are concerned to \$768,809.84.

American Indigo Now Produced.—The Dow Chemical Company, Midland, Mich., has begun the production of indigo in spite of the unfavorable tariff conditions which have held it up for considerable time. The output is 1000 lb. per day of 20 per cent paste.

The Evolution of the McGraw-Hill Publishing Co., Inc.

Through the consolidation, announced on the first editorial page of this issue, of the McGraw Publishing Company, Inc., and the Hill Publishing Company into the McGraw-Hill Publishing Company, Inc., Mr. James H. McGraw, the president of the new company, becomes the pre-eminent figure and predominant influence in American technical journalism. A brief sketch of his life and work and of the evolution of the company which he heads is of particular interest at this time.

James H. McGraw was born in Panama, Chautauqua County, N. Y., in 1860 and graduated in 1884 from the Fredonia Normal School. After teaching school for a few years, he commenced his life as a publisher with the American Railway Publishing Company of New York, then owner of the "Street Railway Journal" and two other papers. Shortly after the dissolution of this company in 1888, Mr. McGraw acquired the "Street Railway Journal."

His acquisition of this property merely started him upon his career as a publisher. The rapid development of electric traction and the consequent obsolescence of the horse car placed him in a strategic position. He had a great influence in the field, and he used it always for the upbuilding of the industry. In fact, it is generally recognized that no one has done so much for the electric railway business as he. He worked not only through his paper, which later was renamed the "Electric Railway Journal," but also through the American Electric Railway Association, in whose work he has taken an active part.

With the growth of electric traction, other developments occurred. Great industries were springing up for the manufacture of electric equipment of all sorts. To so keen an observer as Mr. McGraw, these beginnings of an electrical industry, which was soon to become colossal in its proportions, were significant. Again his vision pictured an immense field for a technical journal. With this conception in mind, he purchased in 1896 "Electrical Industries," which he renamed the "American Electrician," a monthly periodical devoted to electrical and mechanical engineering. Three years later, in 1899, he acquired the two leading electrical journals—the "Electrical World" and the "Electrical Engineer," both of New York. These, with the "American Electrician," were consolidated into one publication, the "Electrical World," now the leading journal of the electrical industry.

To control these properties the McGraw Publishing Company was incorporated in 1899, with Mr. McGraw as president and controlling stockholder. He struck out into new territory in 1902, entering not only into the civil engineering and contracting field by the acquisition of the "Engineering Record," but giving his aid and influence in the autumn of the same year to the formation of the Electrochemical Publishing Company for the purpose of publishing a new monthly, "Electrochemical Industry," as the journalistic exponent of the then young art and science of electrochemistry. In 1905 the scope and name of the paper were enlarged to "Electrochemical and Metallurgical Industry." Again in 1910 the scope was broadened and the name changed

to "Metallurgical & Chemical Engineering." In 1912 the entire stock of the Electrochemical Publishing Company was acquired by the McGraw Publishing Company. Since September, 1915, "Metallurgical & Chemical Engineering" has been published as a semi-monthly. Thus it was left to Mr. McGraw, already the leading technical publisher in the electrical, electric railway, and civil engineering fields, to give to the new professions of the chemical and metallurgical engineers their technical newspaper. The growth of this journal during the past few years has been phenomenal.

The latest additions to the list of McGraw papers were "Electrical Merchandising" and "The Contractor." Since 1906 the McGraw papers have had their own home at 239 West Thirty-ninth Street, New York.

* * *

The history of the development of the Hill Publishing Company, like that of the McGraw Publishing Company, Inc., with which it has become consolidated, is built largely around the efforts of one man. The late John Alexander Hill, founder of the house which bore his name, began his publishing career by the acquisition of "Locomotive Engineering," a paper on whose editorial staff, a few years before, he had been given a position as editor. With Mr. Hill at its head, the journal soon became successful. Hardly had it become firmly established when Mr. Hill sold it and purchased the "American Machinist."

Since its formation in 1902, the Hill Publishing Company has reached a position in the front rank of technical journalism. It had its beginning in the consolidation of the American Machinist Press, publisher of the weekly "American Machinist," and the Power Publishing Company, publisher of the monthly "Power."

In 1905, the weekly "Engineering and Mining Journal" was purchased. In 1908 the semi-monthly paper, "The Engineer," of Chicago, was consolidated with "Power" and the latter paper was made a weekly. In 1911 "Engineering News" was purchased. A new weekly paper, "Coal Age," was started in October, 1911, its field being coal mining and coke manufacture. Four years later the "Colliery Engineer," published in Scranton, was bought and consolidated with "Coal Age." The "Mining and Engineering World," published in Chicago, was acquired in December, 1916, and consolidated with the "Engineering and Mining Journal." A home for the Hill papers was provided in 1914 in the beautiful Hill Building at Tenth Avenue and Thirty-sixth Street.

After Mr. Hill's death in 1916, Arthur J. Baldwin was appointed to the presidency of the Hill Publishing Company. Mr. Baldwin, the new vice-president and treasurer of the McGraw-Hill Publishing Company, Inc., is a lawyer by profession and for many years was closely associated with Mr. Hill.

In 1909 the respective book departments of the McGraw Publishing Company and of the Hill Publishing Company were consolidated into the McGraw-Hill Book Company, which has been eminently successful and is the largest technical book publisher in the world.

This merger has now been followed by the much bigger consolidation of the two publishing companies themselves. Mr. McGraw has realized the dream of a life time.



JAMES H. MCGRAW

The New York Section of the American Chemical Society Celebrates Its Twenty-fifth Anniversary

On Friday evening, March 9, at a joint meeting of the New York Sections of the three chemical societies, the New York Section of the American Chemical Society celebrated its twenty-fifth birthday. The Chemists' Club Hall was prettily decorated with flags and greens and nearly 300 chemists and engineers attended. An elaborate supper introduced the festivities. After that the members were invited to the main hall where sumptuous plans had been made for a smoker and entertainment.

After a brief business session at which officers for the next session were elected (chairman, Dr. Herty; secretary-treasurer, Mr. Roth), Dr. Matthews introduced the first speaker of the evening, Provost Professor EDGAR F. SMITH of the University of Pennsylvania. Professor Smith congratulated the section upon its twenty-five years of existence and thought this to be a very appropriate occasion to look back on the past and see what some of our fellow chemists had accomplished. Our tendency to-day is to rush along with hardly a thought as to what others before us have achieved. Professor Smith then gave a brief outline of the eventful life and remarkable career of Robert Hare, the pioneer electrochemist of America and in many respects of the world. It was Hare who invented the oxy-hydrogen flame torch which gave rise to the founding of the great Bishop Platinum Works, and the Drummond light, at one time the standard for all light-houses. These researches were carried out in a very primitive laboratory in the brewery of Hare's father and most of his time Hare had to devote to details of brewing. It was Hare also who first applied a mercury cathode in aqueous bath electrolysis and produced in this way sodium, calcium, barium, etc. Hare had built a large copper-zinc battery and the current obtained from it he utilized in a hundred different ways. He heated amorphous carbon and produced the first specimen of artificial graphite. He heated lime and carbon and produced calcium carbide. It was Hare, too, who devised the first gas analytical apparatus and Professor Smith had but recently succeeded in acquiring one of Hare's original gas apparatus. Professor Smith spoke in his usual fascinating style and his talk was very much appreciated.

Upon the conclusion, Dr. Baekeland moved that this 25th anniversary be commemorated by the gift of a bronze bust of Hare to the Chemists' Club. The suggestion was enthusiastically received.

The second speaker of the evening was Dr. WM. H. NICHOLS, who in a very elaborate paper outlined the early history of the American Chemical society. Dr. Nichols showed the audience copies of the first announcements, program of the first meeting (1876), constitution and by-laws, membership lists, etc. Of the 140 members who filled the first year's register but five are living to-day. "Like many of the best things of the world the American Chemical Society was founded by a woman" (who suggested the idea to Dr. Chandler).

The third speaker was Dr. E. G. LOVE, who chose for his topic "The First Years of the New York Section." As treasurer of the Society he was particularly interested in the rapid financial growth of the Society.

The first chairman of the section was Dr. A. H. Sabin (National Lead Co.). Dr. Sabin, who was one of the honored guests, received a great ovation and the first "Salamander" of the evening was "rubbed" in his honor. Dr. C. F. Chandler, the dean of American

Chemistry, who was also expected to attend, was unfortunately unable to be present.

During the course of the evening Dr. Chas. A. Doremus presented to the section, in commemoration of its twenty-fifth birthday, a large steel-engraving of the first president of the American Chemical Society, Prof. J. W. Draper, who was a graduate of the University of Pennsylvania and from 1837 till his death in 1882 was professor of chemistry at New York University. He had gained a world-wide reputation through his researches on spectrum analysis and photography.

At the conclusion of the formal addresses refreshments were served and entertainment of the true smoker style was provided for. Dr. E. C. LOVE made a splendid stage manager. It was long after midnight when the celebration came to a close.

Opportunities for Investment of American Capital in Foreign Fields

Discussion Before Mining Engineers

The March meeting of the New York Section of the American Institute of Mining Engineers was held at Whyte's restaurant on Friday evening, March 9. Percy E. Barbour, who presided in the absence of David H. Browne, introduced WILLIAM S. KIES, vice-president of the American International Corporation. Mr. Kies gave an interesting talk on the international financial situation and the possibilities for the investment of American capital in foreign fields, now and after the war.

He explained the great difference which exists in our financial situation now, as compared with that before the war. Up until that time we had always been a borrowing nation, owing on an average 5 billion dollars. In the short space of two and a half years we have paid off all our foreign obligations and at the end of last year had a favorable balance of trade of 2½ billions. Outside of Mexico and the sugar investments in Cuba, we have not had any foreign investments. On account of the change in the financial situation, however, there is and will be considerable American capital available for investment.

In discussing the fields for this capital Mr. Kies first took up the domestic situation. He said America will need capital to keep on building up her own industries, cities, etc. The greatest users of capital here are the railroads, but Mr. Kies said that under their present mongrel rule they will be unable to go into the market and bid for capital, and are not to be considered as good investments. The same is true of public utilities.

In the foreign field China presents the greatest possibilities, excluding the belligerent countries. Money will be needed there for new railroads, public utilities, improvements, etc. The South American situation needs careful study and does not present such glowing possibilities as some people think. Several of the South American countries have bad credit records, and the governments exercise careful control over the building of railroads.

Mr. Kies said that the United States will have a great obligation in being the custodian of capital which the foreign countries will need, and he thinks the gospel of saving and of elimination of waste ought to be spread in every direction in order that we may hold the ground thus far attained and be able to compete favorably with foreign countries after the war.

He outlined the reason for the formation of the American International Corporation, which was to investigate propositions in foreign fields. The company has gathered a vast amount of information especially from Central and South America, and while as yet but

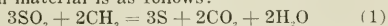
few propositions have been financed owing to their not measuring up to the standard set by the company, several are expected to develop when more capital becomes available. The company may issue bonds in its own name for the financing of foreign propositions.

Mr. J. Morgan Clement was the second speaker, and told of the intention of the U. S. Government to make an investigation of the Mineral Resources of the Far East, at present, especially in China, Manchuria, and the Orient.

The Thiogen Process for Removing Sulphur Fumes

The thiogen process for eliminating the deleterious sulphur dioxide from smelter fumes and converting it into free elemental sulphur as a useful product, has been noticed many times in journal notes and articles. But the only full description of it we know of, has been given in a paper by the inventor, Prof. S. W. Young, of Leland Stanford University, at the San Francisco meeting of the American Institute of Chemical Engineers. From the *Transactions* of the Institute we reproduce Professor Young's paper practically in full in all essentials.

The fundamental chemistry of the proposed process lies in the simple reduction of the sulphur dioxide to sulphur by means of carbonaceous or hydrocarbonaceous materials. In localities where natural petroleum is readily available, it, in some form or other, would be the most desirable material for the purpose. It may be assumed that petroleum is to be used for the purpose, and that their composition is sufficiently closely represented by the formula CH_2 . The theoretical equation representing the reduction of sulphur dioxide by such hydrocarbon material is as follows:



This equation represents the theoretical maximum chemical efficiency which the process could attain under any condition. It will be seen that, working at this maximum efficiency, 28 tons of hydrocarbon would produce 96 tons of sulphur. This is, of course, taking no account of hydrocarbon used as fuel or for any other purpose.

The patents owned by the Thiogen Company cover two general methods of carrying out the above mentioned reduction of sulphur dioxide, one known as the "dry process," and the other as the "wet process." The experimental developments of the two processes have been of wholly different character, and the experiments have been carried out independently.

THE "DRY PROCESS"

If one attempts to carry out the reduction of sulphur dioxide by means of hydrocarbon vapors in combustion tubes, very complex and incomplete reactions occur, which result in considerable evil-smelling vapors and much unattacked sulphur dioxide. Even at temperatures too high to be available for practical operations, the reaction is too slow to be of any use. In the investigations leading to the Thiogen patents, a number of satisfactory catalysts were found. These are all compounds of such metallic elements as yield sulphides readily by reduction of sulphates or sulphites, and whose sulphides are infusible and readily converted back to sulphites or sulphates by the action of sulphur dioxide. Such sulphides as those of calcium, barium and magnesium seem to give the best products for this purpose. A little thought will make clear the probable catalytic action of the compounds of these metals.

If we start with say calcium sulphate and treat it at elevated temperatures with hydrocarbon vapors, it be-

comes reduced to calcium sulphide. If, still at elevated temperature, the sulphide be treated with sulphur dioxide, the following equation represents the reaction which occurs:



A few experiments in the laboratory very soon demonstrated the fact that the reduction of calcium or other sulphate to sulphide and its reconversion to sulphate and free sulphur by means of sulphur dioxide could go on readily side by side. That is, if sulphur dioxide mixed with hydrocarbon vapors in the proper proportions is passed through a heated combustion tube containing fragments of calcium sulphate, the reduction of the sulphur dioxide takes place with great ease and rapidity, and the products are mainly sulphur, carbon dioxide, and water vapor. Little or no carbon monoxide is found unless excess of hydrocarbon is used. This is the fundamental principle of the Thiogen "dry process."

The Penn Mining Company, with a smelter located at Camp Seco, California, placed at the disposal of the Thiogen Company ground space, gases, materials, and money for a very considerable series of experiments on a commercial scale. After one or two series of experiments with various forms of apparatus, experience seemed to point to a vertical reaction chamber as best for the purpose. This was constructed of large iron pipe 5 feet in diameter and 20 ft. high. It was lined with fire brick, and four stationary hearths were built in. On these hearths was placed the contact material. This was made up of plaster of paris, which was sloped and allowed to set, after which it was thoroughly dried and broken into lumps about as large as the hand, so that when installed on the hearths it made loosely porous masses, affording good mixing and contact for the reacting gases. Each hearth was provided with man-holes for cleanout and replacement, as well as with tubulations for gas sampling throughout the period of operation. A system of pyrometers was also installed whereby records of temperatures on all the hearths could be obtained.

Below the fourth hearth were the intake for the roaster gases to be treated, and two crudeoil burners. Two burners were used instead of one, to increase the range and accuracy of regulation. The roaster from which the gases were taken was an ordinary McDougal. It was provided with a by-pass system and fan blower, whereby a part of the gases could be continuously returned through the roaster. It was thus possible to get gases of fairly constant compositions for sufficient periods of experiment, and under favorable conditions it was possible to maintain a fairly steady flow of gas as high as 11 per cent sulphur dioxide, for sufficiently long periods to be useful for experiments.

In beginning a run, the procedure was to first start the oil burners, with air draughts, and to keep up the firing until the contact material on all hearths was a good bright red. The air draught was then cut down and the roaster gases admitted. Analyses were continuously taken from all the hearths. These showed at first complete reduction on the first hearth. After a time this hearth began to cool down and reduction was imperfect. The second hearth, however, showed perfect reduction for a time, when this also began to cool off, and so on until the whole apparatus went out of action. This cooling action could be ascribed to two causes: First, absorption of heat by vaporization of the oil; second, the oncoming roaster gases were too cold (they had been cooled to about atmospheric temperature by a scrubber in order to remove dust).

An outside vaporizing chamber for oil was built, and while this assisted somewhat, the same cooling as before occurred. A rather elaborate pre-heating apparatus for

the gases was then designed, but unfortunately at about this time the company encountered difficulties with their mining operations which made it seem doubtful wisdom for them to continue financing the experiments. So the experiments were terminated. In the meantime considerable valuable information had been obtained which is summarized as follows:

(1) Under favorable conditions the reaction between sulphur dioxide and hydrocarbon vapors in contact with the calcareous material is extremely rapid. It was never possible to force the apparatus beyond capacity.

(2) The process does not offer any hope of working well with gases under 7 per cent in sulphur dioxide. At lower percentages than this considerable sooting occurs, which puts the contact mass out of commission.

(3) In order to operate successfully, the process will demand preheating of the gases. To just what temperature this preheating must go it is impossible to say in absence of experimental evidence. The calculated values do not indicate that it is likely to be an especially difficult matter.

(4) The dry process undoubtedly contains the elements of a successful commercial process for producing sulphur, under the condition that the plant producing the gases will operate for high concentration gases. Seven per cent sulphur dioxide is necessary, and the higher the percentage goes the better, as every drop in sulphur dioxide content means additional oxygen to burn out, and additional oil costs per ton of sulphur.

THE WET PROCESS

The Thiogen wet process proposed to accomplish the same end as the dry process, namely the reduction of sulphur dioxide to sulphur by hydrocarbon vapors or carbonaceous material, but it accomplishes this result in a far different way. It was the first of the two processes to be devised. The general procedure in the wet process is as follows:

(1) The sulphur dioxide is first absorbed in water in appropriate absorption towers. This operation takes place in accordance with well-known laws and needs no further discussion.

(2) This solution of sulphur dioxide in water is mixed and allowed to react with a paste or solution of a suitable sulphide. The most suitable sulphide for this purpose that was found thus far is barium sulphide. When sulphur dioxide reacts with basic sulphides in the wet state, the processes which occur are rather complex. Considerable free sulphur is formed, and in addition, sulphides, thiosulphites and thionates of the metal used. The formation of some complex sulphur salts is a matter of little moment, since in the further operations they break down, and furnish their equivalent of free sulphur.

(3) As a result of the treatment described under (2) there is formed a sludge whose solid components are free sulphur and the sulphur salts of the metal used. If the treatment is properly carried out, these solids settle and filter with greatest ease, and the supernatant liquid is practically pure water, which may again be returned to the absorption towers.

(4) The solids of the sludge, after settlement and filtration are dried, and then raised to a temperature of from 450 deg. to 500 deg. C. In this way the complex sulphur salts are broken down and the total sulphur available as free sulphur is distilled off and condensed. The still residue consists of a mixture of sulphite and sulphate together with some sulphide under certain conditions. The sulphide is formed as a result of the well-known breakdown of sulphites into sulphides and sulphates at higher temperatures.

(5) The residual sulphites and sulphides are next passed through an appropriate furnace where they are

reduced back to sulphide, and are then again ready to be brought into reaction with further quantities of sulphur dioxide solutions. There is thus accomplished a cycle of operations whereby nothing is used up but sulphur dioxide and reducing materials, for which there is produced an output of free marketable sulphur.

The reason for choosing barium sulphide instead of the cheaper calcium sulphides are chiefly as follows:

(1) Barium sulphide is readily and rapidly soluble in water, while calcium sulphide is not. Thus ease of intimate mixing and rapid reaction with the sulphur dioxide liquor is greatly favored by the use of the barium compounds.

(2) The sulphite, sulphate and the complete sulphur salts of barium are much more insoluble than the corresponding salts of calcium. This prevents the building up of any disadvantageous concentrations of these salts in the water used in the operation.

(3) The barium salts all crystallize anhydrous while the calcium salts all carry water of crystallization in considerable amounts. This means a great saving in the heat demanded in process (4) of the cycle, namely the drying of the filtered sludge. If calcium salts are used, the preparation of the solids for distillation would demand not merely the drying away of adherent water, but also the driving off of large quantities of water of crystallization.

(4) The settling and filtering properties of the barium sludges are vastly superior to those of the calcium ones.

All phases of operation of the wet process have been worked out quite thoroughly by Professor Young and his co-workers in the laboratory, and all members of the cycle have been realized practically. The element which offers the greatest difficulty is the reduction of the still residues to sulphide.

As to the relative merits of the two processes, the wet process has the great advantage of operating under present conditions of roaster and blast furnace operations, namely low concentration of sulphur dioxide. On the other hand, Professor Young still firmly believes that wherever roasting for high concentration could be introduced, the dry process would prove the more economical for the production of sulphur.

Actual Work Begun in Course of Chemical Engineering Practice

In his report recently made to the Massachusetts Institute of Technology Alumni Council with reference to the opening of the new course in chemical engineering practice (see this journal, Aug. 1, 1916, Vol. 15, p. 138), Dr. W. H. Walker, director of the course, noted particularly the conditions at Bangor and Stamford, places which he had just visited. Both students and manufacturers are very enthusiastic about the work.

"At Bangor the students are engaged this week in a survey of the processes of the Penobscot Fiber Company, at Great Works, Me., where their study will be losses of soda in various processes, data which the manufacturers much desire but which it has not heretofore been convenient to secure. The presence in any plant of a group of young men who can devote their time and efforts to definite research work in the minutiae of the processes is likely to afford information of value in the refinement of the technique. At Bangor this group has already made an elaborate test of the electrolytic plant of the Eastern Manufacturing Company, the products of whose processes are chlorine and caustic soda.

"At Stamford the students have had considerable experience in the handling of machinery and outfit in addition to chemical work."

Current Density in Copper Refining

By Lawrence Addicks

The current density, or amperes per square foot of active cathode surface, is the factor in an electrolytic process, such as copper refining, upon which above all others the design and operation of the plant depend, as upon it hangs a string of minor factors which must be properly correlated in order to obtain the best return upon the investment. These factors may be classified under cost per pound of cathodes recovered, first cost of plant, and metallurgical purity of product.

Aside from commercial considerations there is a limit to the density which can be employed imposed by the temperature of the electrolyte. By far the larger part of the electrical energy called for is converted into heat in overcoming the ohmic resistance of the cells and the temperature of the electrolyte rises until the heat losses offset the C'R gain.

The electrodes are spaced so closely in the tanks that the equivalent energy to be dissipated is quite large and further at about 150° F. a liquid will begin to steam sufficiently to make a tank room too foggy for comfort or for efficient inspection. As a starting point we may first examine this question of temperature of electrolyte.

Temperature of Electrolyte

In ordinary practice with moderate densities the electrical energy is supplemented by a certain amount of either live or exhaust steam to obtain the desired temperature of operation generally in the neighborhood of 130 deg. Fahr. This requires a balancing of the cost of heating against the gains resulting. In a previous article (Analysis of Tank Resistance in Electrolytic Refining, Nov. 15, 1916) we have considered in detail the question of tank resistance and took as an example a certain case which showed the distribution of resistance shown in Table I.

TABLE I—TANK RESISTANCE

	Ohms per Tank	Per Cent of Total	Class
A. Electrolyte	0.000044	55.1	Ohmic
B. a. Leads	0.000024	3.0	Ohmic
b. Conductor bars	0.000085	10.5	Ohmic
c. Anodes	0.000002	0.25	Ohmic
d. Cathode rods	0.000010	1.2	Ohmic
e. Cathodes	0.000008	1.0	Ohmic
f. Connection strips	0.000002	0.25	Ohmic
C. a. Anode contact	0.000026	3.2	Ohmic
b. Cathode loop contact	0.000043	5.3	Ohmic
c. Cathode rod contact	0.000014	1.7	Ohmic
D. Counter electro-motive force	0.000040	5.0	E.M.F.
E. Slimes, etc., by difference	0.000078	9.7	Ohmic
Total	0.000806	100.0	

Increasing the temperature of the electrolyte will lower its resistance by an amount proportionate to the increase and to its temperature coefficient of about 0.5 per cent per degree Fahr. It will increase the resistance of the various metallic resistances and contacts which it can affect.

As the anodes and cathodes are the only submerged metallic resistances and as they are of negligible resistance, we may turn to the exposed resistances and contacts. The leads and conductor bars along the sides of the tanks are too far removed from the source of heat to be much affected. The contacts are kept well above room temperature by their own C'R loss.

The temperature coefficient of copper is plus 0.24 per cent per degree Fahrenheit.

I think we may safely assume that the total change in these minor resistances with change in temperature of the electrolyte is very small. The "transfer" resistance at the surfaces of the electrodes is markedly low-

ered by increase of temperature, but this gain is large only in the lower part of the temperature range.

We may therefore consider the temperature coefficient as approximately minus 0.5 per cent. per degree Fahrenheit at high temperatures and a larger figure at low temperatures due to the added change in "transfer" resistance.

When running at about sixteen amperes per square foot of cathode surface without the use of any steam for heating, the electrolyte in an average system will run about 25 deg. Fahr. above the temperature of the atmosphere in the tank room, which latter is generally around 70 deg. Fahr. and very humid unless an adequate system of forced ventilation is employed.

Some simple tests where a circuit was allowed to run without any heating steam until at temperature equilibrium and then heating as rapidly as possible in the solution wells showed the results given in Table II.

TABLE II—EFFECT OF TEMPERATURE OF ELECTROLYTE ON TANK RESISTANCE

Test No.	OHMS PER TANK			DEG. FAHR.			Ohms per Degree	Temp. Coeff. per Cent
	Initial	Final	Diff.	Initial	Final	Diff.		
1	0.000094	0.000089	0.000005	102	121	19	0.00000026	0.29
2	0.000097	0.000087	0.000010	103	122	19	0.00000033	0.51
3	0.000091	0.000082	0.000009	108	128	20	0.00000015	0.55
4	0.000095	0.000088	0.000007	105	118	13	0.00000061	0.69
Av.	0.000095	0.000087	0.000008	105	122	17	0.00000017	0.54

Current=4400 amperes Watts per tank without steam=1840

This temperature coefficient of 0.54 per cent per degree Fahrenheit is so large that it at once becomes apparent that the application of direct heat to the electrolyte should be considered. Some interesting tests were carried out at another plant by measuring the temperature of the electrolyte, amperes and voltage

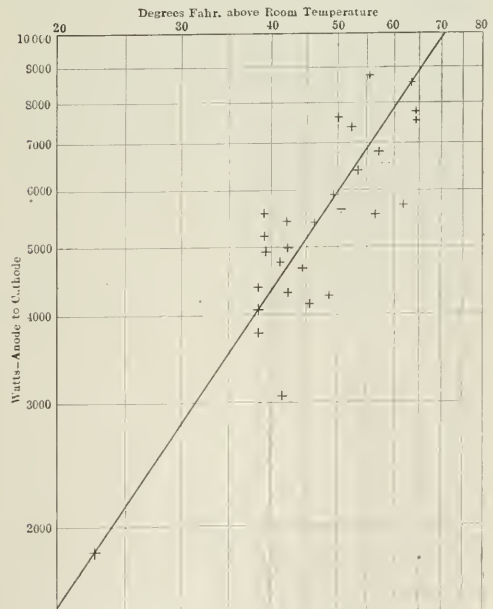


FIG. 1—WATTS TO MAINTAIN TEMPERATURE OF ELECTROLYTE

from anode ear to cathode loop, for different current densities without direct heat.

Some of the results obtained are shown in Fig. 1. The watts per tank required to maintain a certain temperature is a measure of the rate of cooling at that temperature and the curve is therefore exponential. Plotting the data on logarithmic section paper indicates a law of

$$\text{Watts per tank} = 20.8 \times (\text{° Fahrenheit liquor} - \text{° Fahrenheit atmosphere})^{1.46}.$$

This formula is, of course, only good for the conditions at the particular tank house where the tests were conducted. At a room temperature of 70 deg. Fahr. this formula would give our practical limit temperature of 150 deg. Fahrenheit in the electrolyte with 12,000 watts per tank.

Under the conditions of this set of tests the internal tank resistance would be about 0.00003 ohm and 12,000 watts would correspond to a current of 20,000 amperes and a current density of 64 amperes per square foot. This is far above any density ever likely to be applied in practice unless marked changes in the general arrangement of the process develop.

With a density of 45 amperes per square foot the electrolyte would probably run about 120 deg. Fahr. and the use of steam for heating would hardly be justified. At lower densities we have the usual case of heating in the solution wells by steam.

If we figure out a heat balance between live steam for heating and the saving at the boilers for decreased electrical power for electrolysis we shall find that the total cost increases as the electrolyte is heated.

The earlier plants did use live steam for heating but the more recent installations have used exhaust steam. In some cases obtained by operating some of the main generating units under partial vacuum, and this changes the entire situation.

Another result of heating the electrolyte is to increase the growth of copper in solution due to the oxidizing effect of the liquor. Copper is not ordinarily considered soluble in dilute sulphuric acid but when the solution is aerated by passing from tank to tank the oxygen dissolved brings about slow solution.

Fig. 2 shows the rate of action of a solution carrying 3 per cent. copper and varying percentages of free acid upon a piece of cathode copper about 3 x 3 inches, as the temperature is raised in a beaker. This shows that the degree of attack rapidly increases with rising temperature, and is practically independent of the degree of acidity. This action may or may not be desirable according to circumstances.

Where quite pure anodes are being refined the excess

copper builds up in the electrolyte and is usually removed by means of insoluble anode or "liberating" tanks. As these operate at from 2.0 to 2.3 volts or some seven times as much as ordinary depositing tanks require, this power tends to offset the resistance saving due to hot electrolyte.

When, on the other hand, the anodes carry considerable percentages of nickel, cobalt, etc., a proportion of the current is employed dissolving these substances electrochemically at the anode while depositing an equivalent quantity of copper at the cathode, so that the nickel, etc., will grow in the electrolyte which is at the same time depleted in copper. Then the addition of copper by chemical corrosion is very welcome; in fact in extreme cases this effect has to be artificially increased by the use of towers of shot copper or similar means.

In general it is found necessary to use from 2 per cent of liberating tanks at one extreme to no liberating tanks and shot towers at the other.

The temperature of the electrolyte also has a bearing upon the shrinkage in volume in the electrolyte due to evaporation. Now that it is customary to use a purifying process on a closed cycle evaporation gives almost the only means of making room for water used in rinsing the anodes and cathodes.

The final and really controlling reason for the use of warm electrolyte is the greatly improved metallurgical conditions resulting therefrom. Not only is the cathode smoother and denser, but the conditions at the dissolving surface of the anode are greatly benefited.

The increased temperature brings about a local circulation which assists in removing the dense solution of copper sulphate from the face of the anode and in preventing stratification in the tank.

When current is passed through a cold cell without any circulation of the electrolyte conditions soon become so unbalanced that the electrodes will gas, the voltage show violent fluctuations and the anode slimes be stirred up and carried in suspension, thereby fouling the cathode.

When the electrolyte is systematically circulated these bad effects are counteracted, but the rate of circulation which can be employed is limited by the eventual stirring up of the slimes mechanically.

There is in turn a current density for this limiting circulation which begins to bring about a return of the undesirable gassing and for a cold liquor and an impure anode this density is so low as to require an abnormally large plant investment.

When the electrolyte is heated this density limit is greatly raised and it was practice even in the very early days to heat the electrolyte somewhat—perhaps to 110 deg. Fahr.—and later this temperature has been gradually increased until 135 deg. Fahr. entering the tanks is not uncommon.

In series system plants the tanks have commonly been lined with some asphalt composition which softens with heat and this has made it impracticable to use temperatures as high as would be otherwise desirable, and is one of the reasons that series processes require relatively pure anodes.

In general, therefore, (1) the temperature of the electrolyte should be carried well up toward the practical limit of 150 deg. Fahr. in order to be able to employ as high a current density as may be desirable from the point of view of cost of operation; (2) unless a very high density permitted by very unusual conditions is employed, heating in the solution well will be required to maintain this temperature; (3) with proper exhaust steam design this heating will be practically free of direct expense.

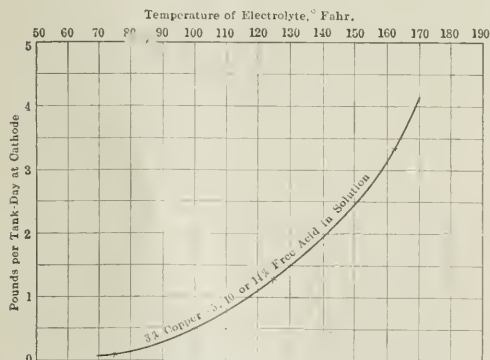


FIG. 2—CHEMICAL CORROSION OF COPPER BY ELECTROLYTE

Power

Assume a tank resistance of 0.0000766 ohm, a counter e.m.f. of 0.010 volt per tank, 24 pairs of 2 ft. x 3 ft. anodes and cathodes, making 288 sq. ft. of surface and 90 per cent current efficiency. As we increase the current density we shall have the conditions shown in Table III.

TABLE III—RELATION BETWEEN CURRENT DENSITY AND POWER COST

Amperes per Sq. Ft.	Amperes	Volts	Watts	Lbs. Copper per 24 Hours	Watt-Hours per 24 Hours	Watt-Hours per Lb. Copper
5	1,440	0.120	173	81	4,200	52
10	2,880	0.231	665	162	16,000	99
15	4,320	0.341	1,470	243	35,300	145
20	5,760	0.451	2,600	324	62,400	193
25	7,200	0.562	4,050	405	97,200	240
30	8,640	0.672	5,810	486	139,400	287
35	10,080	0.782	7,900	567	189,600	335
40	11,520	0.892	10,260	648	246,200	381

This table shows that the power cost per pound of copper rises nearly in proportion to the current density employed.

It is true that we have assumed a constant tank resistance due to maintaining the electrolyte at a constant temperature by means of steam.

As the current density is raised the electrical heat dissipated in the tanks will increase, as previously discussed and this will mean that less heating steam will be required and this saving will give some credit to be applied against the power cost.

It is evident that the cost of producing a kilowatt-hour will have a great deal to do with the question; in fact it is possible to plot the power cost at various plants against the current density used and obtain quite a smooth curve. Fig. 3 shows this general relation, but individual cases may show exceptions for special reasons.

First Cost of Plant

Assume that the tank house equipment in the example taken amounts to an investment of \$300 a tank and that the power plant costs \$80 a kilowatt. As the former will vary with the output of cathodes per tank day and the latter with the kilowatt demand, both of which depend upon the current density, we can take the relations determined in Table III and ascertain the

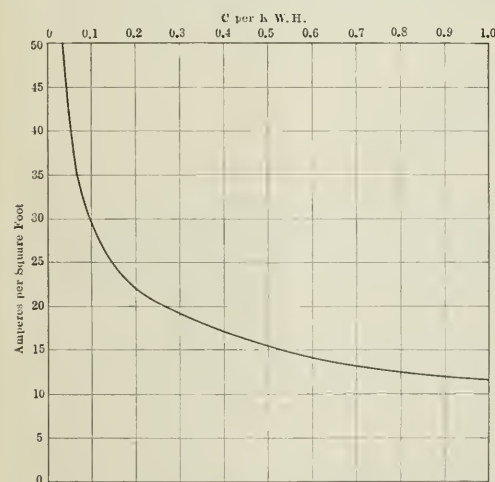


FIG. 3—CURRENT DENSITY VS. POWER COST IN PRACTICE

joint influence of these two factors, which has been done in Table IV.

TABLE IV—RELATION BETWEEN CURRENT DENSITY AND COST OF PLANT

Current Density	Lbs. Copper per Tank-Day	Tank Investment per Lb. Copper per Day	Watt-Hours per Lb. Copper	Watts per Lb. Copper per Day	Power Plant Investment	Total Investment per Lb. Copper per Day
5	81	\$3.60	52	2.16	0.17	\$3.77
10	162	1.85	99	4.12	0.33	2.18
15	243	1.23	145	6.04	0.48	1.71
20	324	0.92	193	8.06	0.65	1.57
25	405	0.74	240	10.00	0.80	1.54
30	486	0.62	287	11.90	0.95	1.57
35	567	0.53	335	13.90	1.11	1.64
40	648	0.46	381	15.80	1.26	1.72

Labor Cost

The main labor items in operating a tank house are for inspection work to maintain current efficiency and for inserting and drawing the electrodes as the copper moves through the process.

The higher the current density the more difficult is it to maintain the efficiency on account of the increased number of short circuits caused by rough deposits on the cathodes.

After the circulation of the electrolyte has been raised to the highest rate which will not stir up slimes and addition agents have been added to control the character of the deposit as much as possible, the only ways to maintain efficiency are either to steadily increase the inspection labor or to decrease the life of the cathodes.

Actually as the density rises the efficiency in practice is sacrificed a little, the labor is increased and the age of the cathodes decreased until a balance is struck.

The cost of making starting sheets in the multiple process also enters if the weight of the individual cathodes is changed. We shall confine ourselves to an inquiry into the effect of age of electrodes upon the labor cost.

Age of Electrodes

The age of the anodes and the proportion of anode scrap made have but little connection with the current density, except that four anodes which give heavy scrap

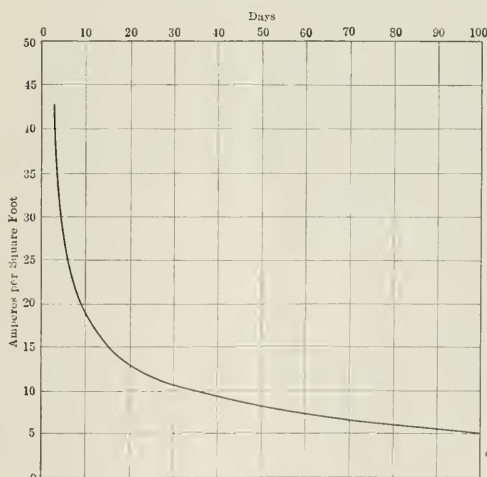


FIG. 4—CURRENT DENSITY VS. AGE OF CATHODES IN PRACTICE

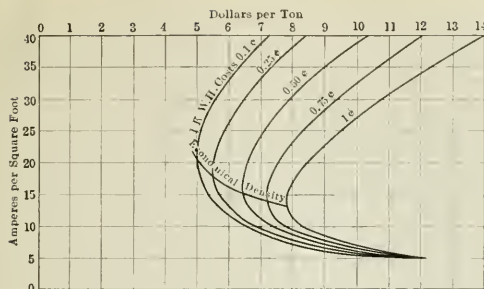


FIG. 6—CURRENT DENSITY VS. VARIATION IN TOTAL OPERATING COSTS

It will be observed that the two curves for theory and practice agree well except at the lower power costs where practice runs at a higher current density than would be expected from our discussion.

This is due largely to the fact that although a certain density may show minimum cost a higher density may show maximum profits. For example suppose that a plant operates with power costing $\frac{1}{4}$ cent per kilowatt hour at the density for lowest cost shown by our curve in Fig. 7 to be 18 amperes per square foot, and that the profit from refining is pushed up to 25 amperes a square foot the cost by Fig. 6 will be increased about \$0.33 a ton and the profit per ton be cut to \$2.67; but the increased density will allow the plant to treat 38 per cent more copper so that instead of \$3.00 we make an equivalent of 1.38 by \$2.67 or about \$3.70.

This argument is fallacious where we are designing a plant for a certain tonnage, as our calculations have shown that the \$0.33 excess cost would pay more than 20 per cent on the increased investment to bring the density back to 18 amperes per square foot, but practically a plant after being put into operation is crowded by the steady annual growth in the production of copper and we may say is unable to keep up with this demand for capacity by extensions.

On the other hand where power is expensive this process of expansion receives a much earlier check than

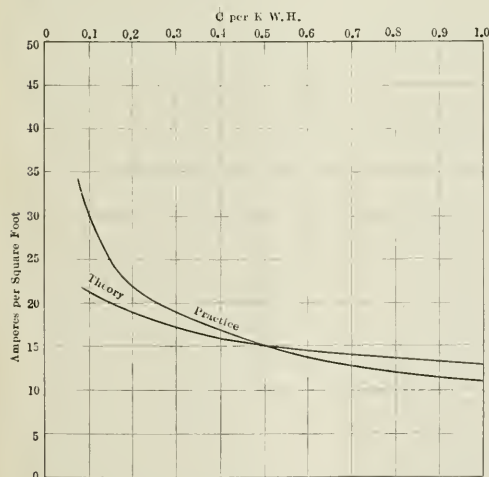


FIG. 7—CURRENT DENSITY VS. POWER COST—THEORY VS. PRACTICE

where it is cheap and this tends to explain at least part of the difference between theory and practice.

Then too at very low power costs we must be considering water power installations and this not only affects the investment factor we have assumed for steam plants, but introduces the question of secondary water power where excess power allowed to run to waste over a dam may be utilized at exceedingly low rates. Also the assumptions of interest rates, price of copper and silver and gold values have to be corrected for each practical case.

The Fixation of Nitrogen as Cyanide

A very interesting lecture was delivered by Prof. John E. Bucher of Brown University, Providence, R. I., on this subject on the afternoon of March 2, at the College of the City of New York. The lecture was one of the regular series of public lectures given by the Chemistry Department of the College. Professor Bucher described in the most vivid manner his experiments on the production of sodium cyanide by passing a current of nitrogen over a mixture of soda ash, coke and iron filings. The lecture covered much the same ground as his recent paper before the American Institute of Chemical Engineers, abstracted in our issue of January 15, page 82. But a fuller account of the work of Professor Bucher in this field should prove particularly interesting to our readers at the present time.

The address was given in the chemical lecture room of the college and Professor Bucher had considerable apparatus set up to show how the various processes described were conducted. The time did not allow of the performing of but one or two experiments, but the apparatus, together with many samples, served to elucidate the description of the processes. After the lecture Professor Bucher answered many questions and explained some of the apparatus in greater detail.

The reactions which were studied by Professor Bucher in his work are not new, and he first took up the history of the subject. Lewis Thompson, in 1839, described in the "Mechanics Magazine" (London) experiments made on the manufacture of cyanide and its conversion into Prussian blue. He ground two parts of pearl-ash, two parts of coke and one part of iron turnings into a coarse powder and heated this in an open crucible to a full red heat for half an hour. He obtained potassium cyanide from this, which he converted into Prussian blue. Particular attention was called by Professor Bucher to the fact that Thompson stated that iron was necessary in the process if it was to be carried out at a moderate temperature. In 1843 Newton took out a patent for the production of cyanide, using atmospheric nitrogen. A factory was built at Newcastle-on-Tyne which produced yellow prussiate of potash for some time, but finally failed in 1847 owing to the non-use of iron and the consequent necessity of operating at a very high temperature.

Victor Alder of Vienna took out patents in Germany in the years 1881 to 1885, in which it was stated that iron could be used but that it was not absolutely necessary to use it, and that the process would work all right without iron. Attempts to work the process according to these patents for several years in Germany finally resulted in failure. Thus the original condition for successful working as originally established by Thompson was overlooked in the practical work following.

Professor Bucher mentioned that he had done work on a magnesium nitride process, forming the nitride from metallic magnesium and nitrogen. This when heated with ammonium chloride gives ammonia and

magnesium chloride. He did not, however, go into this in any detail.

The first experiments discussed were those on the fixation of atmospheric nitrogen with alkali metal according to the equation:

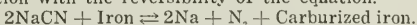


A $\frac{1}{2}$ in. malleable iron pipe about 30 in. long was inclosed in a larger horizontal pipe so that the inner pipe could be surrounded with hydrogen or nitrogen to prevent diffusion of carbon dioxide into the inner tube. This inner tube was filled with lampblack and heated to a white heat in a current of hydrogen. Sodium was then placed in one end of the tube and nitrogen passed through and allowed to bubble through water in a flask at the other end. If nitrogen is absorbed, then a partial vacuum is created and the water will rise in the tubing toward the iron tube. In the experiments with metallic sodium and lampblack or graphite the water rose very slowly, indicating a slow absorption of the nitrogen. It was found to require hours to get much absorption.

Using the same apparatus and adding finely divided iron to the charge made a marvelous change in the rate of nitrogen absorption. In this case the water backed up so rapidly that there was scarcely time to turn the nitrogen on full force to keep the water from entering the tube and reacting with the sodium. In this case 94 per cent of the sodium was converted into cyanide and fused globules of iron were found in the tube, indicating the strongly exothermic nature of the reaction. The catalytic action of iron was thus seen to be extremely strong.

This experiment led to the testing of this process for the purification or decarbonization of iron. Professor Bucher showed several small hack-saw blades which had been heated in a current of nitrogen and sodium vapor to a dull red heat for several hours. They were very soft and silvery in appearance and could be bent into any shape without breaking. He then reheated one of the blades to a good red heat and quenched it. It still remained soft, thus showing the absence of carbon. He then made one of these blades the anode in a beaker of dilute hydrochloric acid. The blade remained silvery white and no carbon was deposited. On making an untreated blade an anode in the same solution and turning on the current a few minutes, carbon was quickly deposited on the bottom of the beaker. The sodium was stated to remove not only carbon but also phosphorus and sulphur.

The utilization of this reaction for the preparation of carbon-free metallic iron was also discussed in connection with the reversibility of the equation.



This is the equation for the case hardening of iron, and when experiments were made with a mixture of sodium cyanide and pure iron powder and heated in an iron tube considerable metallic sodium was found in the colder part of the tube.

The next set of experiments discussed were those in which sodium carbonate was used instead of metallic sodium. In experiments made without the use of iron with a mixture of powdered graphite and sodium carbonate, heated in a $\frac{1}{2}$ in. copper tube at 920 deg. C. in a current of nitrogen, only a very small amount of sodium was formed and no cyanide. The fact that sodium was found, however, indicated that sodium carbonate and carbon do react to give metallic sodium.

Following these experiments, tests were made using mixtures of graphite, iron and sodium carbonate and heating in the $\frac{1}{2}$ in. tube in a current of nitrogen at 920-940 deg. C., as before. In this case the product gave 60 per cent of the sodium carbonate converted into

cyanide. These experiments with iron showed that Thompson's original statement that iron was necessary is correct and that the cause of failure of subsequent work was the neglect of this condition. From the results of a large number of tests on pipes of many lengths and diameters, it was found that 2-in. pipes 10 ft. long were the most efficient.

The inconvenience of using powder led to the development of a system of briquetting, in which advantage is taken of the solubility relations of sodium carbonate. Hot water is added to the mixed charge of coke, soda ash, and iron. The maximum temperature of a sodium carbonate solution is 104.75 deg. C. The percentage of carbonate (about 30 per cent) in the solution does not change much until the temperature is lowered to about 35 deg. Then $\text{Na}_2\text{CO}_3 \cdot 10 \text{ H}_2\text{O}$ crystallizes out rapidly down to about 12 per cent Na_2CO_3 at 10 deg. The mass is mixed with the water at as near the maximum temperature as convenient, thus giving a range of 70 deg. C. through which the mass might cool before the water would be taken up by the crystals to form the dry hydrate, $\text{Na}_2\text{CO}_3 \cdot 10 \text{ H}_2\text{O}$. Many tons of briquets were made in this manner. At first an ordinary concrete mixer without steam jacket was used, but later a steam-jacketed kneading machine was found more convenient. Small briquets were made from the hot mixture by a small meat chopper, such as found in every household. One of these will produce 5000 lb. of briquets in 24 hours. The briquets should be dried rapidly so as to get them hard. Hot waste gases are good for this purpose. On a commercial scale, iron scale was used and ground to 100 mesh in a ball mill. One hundred mesh coke was then added and then soda ash. With these briquets charges were put through which ran 28 per cent NaCN when finished.

Experiments were then made to determine the percentage of soda ash which would give maximum commercial efficiency and not cover the catalytic iron surface so as to render it sluggish. Three tests were made with the iron-coke-soda ratios 2:2:1, 1:1:1, and 1:1:2, respectively. These experiments showed that the 20 per cent soda ash briquets were the most reactive and that the reaction diminished as the soda ash was increased beyond that point. Also a higher temperature is required for the higher soda ash content.

In conducting experiments with the tube horizontal it was found that the briquets often sagged, forming a channel over the charge. The nitrogen upon being introduced quickly found this channel, and consequently there was little conversion to cyanide. This difficulty was overcome by placing the retorts or tubes vertically.

In connection with the question of loss of alkali by volatilization, experiments were made with continuous oil-burning furnaces with continuous feed of the charge in at the top and continuous withdrawal by conveyor at the bottom. Trouble was experienced by the plastic briquets hardening in the conveyor so that it could not be turned. The reaction tube was made longer so that the worm conveyor could be placed about 4 ft. below the bottom of the furnace. This gave the briquets a chance to cool and they passed through the conveyor all right. They stuck to the pipe, however, in descending, and consequently it was found advisable to use an enlarged section of pipe for the lower end of the furnace, or to cool this lower end.

In taking up the discussion of electric heating of the charge, Professor Bucher showed several tubes in which electric heating had been done. The first one with which he experimented was a section of $1\frac{1}{2}$ -in. galvanized iron pipe about 3 ft. long and with copper hands on each end. In electrical heating a resistor outside the tube may be used, the tube itself may be used

as resistor, or the charge may be used as resistor. Professor Bucher says the ideal way to heat the charge if it is done electrically would be to use the charge itself as resistor. With the above-mentioned galvanized iron pipe as resistor and furnace combined, a test was made with the pipe surrounded with magnesia asbestos to prevent oxidation. The zinc rapidly burned off the furnace, when the current was turned on, but the test worked satisfactorily and the resulting briquets gave 22 per cent sodium cyanide.

With an apparatus rigged up with a 15-kw. welding machine in place of a transformer and using a 4-in. iron pipe 6 ft. long as the resistor and furnace combined, charges were put through which gave 25 per cent NaCN consistently. Professor Bucher had one of these welding machines on exhibit. Vertical iron wires surrounding the furnace and suitably spaced from each other have also proven successful as resistors when properly protected from oxidation. Professor Bucher had a set of these wires connected up and showed how they heated up with the current on. The resistance increase could be plainly seen from a large ammeter on the wall as the current dropped on rise of temperature.

An interesting experiment was described with molten iron as follows: A cylindrical electric furnace with a bottom like a Bessemer converter contained molten iron and coke fragments pressed down from the top by the top electrode. Sodium vapor and nitrogen were blown in at the bottom and cyanide distills out at the top. The only drawback is the necessity of ashless carbon.

Air may be used instead of nitrogen by first passing it over hot coke and fixing the oxygen as carbon monoxide. The coke may be placed as a layer in the furnace with the briquets. Similarly, producer gas could also be used. Experiments with air were entirely successful.

Distillation in a copper tube at 1000 deg. C. and 2 mm. pressure gave good results. The great promise of this method is threatened by the ash from the coke accumulating with each repetition until it stops the process. Ashless carbon is, therefore, necessary. It was thought that the reaction $2CO \rightleftharpoons C + CO_2 + 38,080$ calories might be taken advantage of. At 1050 deg. C. this reaction gives almost pure CO, while at 500 deg. C. it is almost reversed.

Experiments along this line brought out the fact that with iron as a catalyser the reaction proceeded with the formation of C and CO_2 with great rapidity. It gives ashless carbon in the form of lampblack and also 38,080 calories of heat.

With electrical heating the oxidation of the iron pipe is prevented by keeping oxygen away from the outside of the pipe. With fuel-heating the problem of oxidation must be seriously considered. Thousands of experiments have shown, however, that no difficulty need be experienced from this source if proper recognition is given to the proportions of CO and CO_2 present. If producer gas is used, hydrogen might be admitted with the gas. Copper tubes would also avoid oxidation and nickel sheathing has also held out some promise.

Among the various compounds which can be made from the cyanide is sodium ferrocyanide, which can be made by adding hot water to the cyanized briquets to make a stiff paste and then steaming them in an agitator for several hours. The mass is then filtered and the black powder turned into the process again. The filtrate deposits ferrocyanide crystals out on cooling.

By adding caustic soda to the sodium cyanide solution and boiling, ammonia and sodium formate are successfully made. Other products mentioned by Professor Bucher as offering possibilities are urea and oxamid.

Salt Manufacture by Solar Evaporation of Sea Water

By Leroy A. Palmer

The operations of the Western Salt Company at the south end of San Diego Bay in Southern California are typical of present-day practice in the refining of high-grade salt by solar evaporation.

NATURAL CONDITIONS

The source of supply is the water of San Diego Bay, a long and narrow land-locked arm of the Pacific Ocean. The bay has a very narrow entrance situated at the extreme northern end, so that the water does not change completely with each ebb and flow of the tide. This condition, together with the facts that the inflow of fresh water is small and the evaporation high, tends to a natural concentration of the solids, so that the proportion in the water at the southerly end of the bay, where the plant is situated, is somewhat higher than in the ocean water.

Detailed analyses of the water of San Diego Bay are not available, but some samples run for sodium chloride have shown as high as 4 to 5 per cent NaCl.

Two analyses of the ocean water gave the following results:

Substance.	Per Cent.
Na Cl	2.67
Mg Cl	0.322
Mg SO_4	0.197
K Cl	0.129
Ca SO_4	0.163
Na Br	0.042
Ca CO_3	0.017
Mg Br	0.002
Na, CO_3	0.014
Fe, O_2	0.003
Na I (or Mg I)	0.0024
Other solids	0.004
	0.025

In the manufacture of salt by this process the amounts of evaporation and precipitation will, of course, play an important part, the former promoting and the latter retarding the crystallizing of the salt from the water. The site chosen for the location of the plant is such as to give a net annual evaporation of 50 in., a total evaporation of 60 in. against an average precipitation of 10.01 in.

POND SYSTEM

This company was seriously damaged by the heavy floods of January, 1916, and has not yet gotten back to its former equipment or scale of operations. In the following description the practice as indicated by the number and area of the ponds is not strictly in accord-



FIG. 1—EVAPORATION PONDS ON SAN DIEGO BAY

ance with present methods but pertains rather to those followed prior to the flood and which will closely approximate those to be used when damaged dikes can be repaired and other changes made.

The first step in the process is the admission of the bay water to the tide ponds. There are four tide ponds, having a total area of 250 acres, three of them equipped with 16 ft. and one with 8 ft. tide gates. The ponds are surrounded by a levee 10.5 ft. high and three miles long. The water is admitted at high tide, which reaches an average maximum of 7.4 ft. The density² of the bay water as admitted is 17 deg. salometer (4.4 deg. B.). The water is retained in the tide ponds until the next high tide, two weeks, just preceding which it is transferred by pumping.

Pumping is by two centrifugal pumps, operating in parallel by direct connection to a 50 hp. motor. The combined capacity is 15,000 gal. per minute. Each pump has a 36 in. suction and a 24 in. discharge, the two discharge pipes uniting in one main 36 in. line. By this means the water is lifted eight feet to a sump, from which it flows to the high point of the secondary ponds, among which it is distributed by means of gates between the ponds. These secondary ponds, shown in Fig. 1, are nine in number and have a total area of 333 acres.

At the end of two weeks, time for another flow to the tide ponds, the water has reached a density of about 26 deg. S. (6.77 deg. B.), and is concentrated in the lower secondary ponds to make room in the upper ponds for another pump run.

Evaporation is continued further in the secondary ponds until a density of 36 deg. S. (9.26 deg. B.) is reached. The secondary ponds are sometimes referred to as the "lime ponds," as the calcium carbonate deposits from the brine and settles to the floor of the pond at about 30 deg. S. (7.82 deg. B.).

From the last of the secondary ponds the brine is run to the pickling pond, which has an area of 112 acres. Here evaporation is continued until the brine has a density of 100 deg. S. (24.1 deg. B.). Gypsum (calcium sulphate) commences to settle out at 55 deg. S. (13.78 deg. B.) and is practically all thrown down by the time the density reaches 100 deg. S.

When this density is reached the brine is drained to the crystallizing pond of 51 acres, and at 106 deg. S. (25.2 deg. B.) the salt commences to deposit.

As stated, the net annual evaporation on San Diego Bay is approximately 50 in. The density of the water in the crystallizing ponds is such that one inch of salt is thrown down for each six to seven inches of evapora-

tion, so that the annual deposit of salt is from seven to eight inches. As one acre inch of salt weighs approximately 110 tons, this gives a crop of 770 to 880 tons per acre. It has been found that a depth of six to eight inches allows of the most economical harvesting.

Evaporation is continued in the crystallizing ponds to a density of 130 deg. S. (29.67 deg. B.), and the brine then transferred to the bittern ponds. Up to 132 deg. S. (30 deg. B.) the sodium chloride will crystallize out pure with the exception of a small amount of magnesium chloride, but above 132 deg. other salts will deposit, magnesium sulphate being the first to be thrown down.

When the brine is drawn off from the crystallizing ponds, the salt remains as an incrustation, showing typical isometric crystals characteristic of halite, Fig. 2. Many of these crystals are large, an inch or more in diameter, and exhibit a beautiful rose pink color due to the presence of magnesium chloride.

HARVESTING AND WASHING

Harvesting is usually commenced the latter part of August and continued until the latter part of November. It has been found that the most economical practice is to use the rather primitive method of hand shovelling, as this prevents cutting too deeply and bringing up impurities with the salt.

The crystallized salt is shovelled to small two way dump cars on 36 in. tracks, which can be shifted from time to time to keep them within easy reach of the shovellers. The train of cars is hauled out of the crystallizing pond by a gasoline locomotive and dumped to a shallow bin. The bin is V shaped, 100 ft. long, 4 ft. wide, with sloping sides, and 4 ft. deep. It is provided with 31 rack and pinion gates in the bottom, operated from above by hand wheels, by means of which the salt is discharged through the bottom to a screw conveyor, which works it to a belt elevator.

The elevator raises the salt 10 ft. and dumps it to the washer, which is simply a box or trough 30 ft. long, 2 ft. wide and 4 ft. deep, with a screw conveyor in the bottom. The washing is accomplished by working the salt through this trough by means of the screw conveyor against a current of a density of 50 deg. S. (12.5 deg. B.), which is pumped from the pickling pond. The trough is kept full of the brine, which flows back to the pond after passing through. During the process the density of the wash water is increased to 100 deg. S. by the salts which it dissolves. This wash water is raised from the pickling pond by a 3 in. centrifugal pump and delivered to a small pond near the washer, from which a 5 in. centrifugal raises it to the washer.

The screw from the washer delivers the salt to a bucket elevator running on an angle of 45 deg. with a vertical lift of 50 ft. Near the foot of the elevator it

²The figures for density given in this article, both in salometer degrees and in Baume degrees, were supplied by the company. While the usual salometer scale gives directly the percentage of salt in solution, a different salometer scale is used, the idea being evidently to get a wider range of figures and permit greater accuracy.

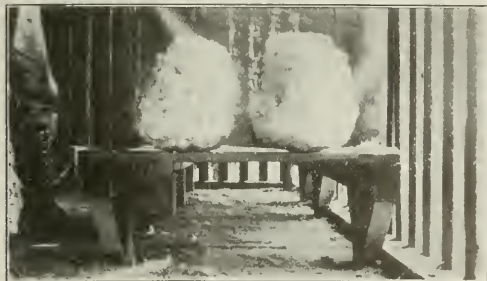


FIG. 2—SALT SHOWING ISOMETRIC CRYSTALS AS DEPOSITED



FIG. 3—TRESTLE AND STOCK PILES

receives a final brine washing by a drip from the pump line and as it is elevated it passes under two perforated pipes, which spray it with fresh water. This removes any dirt or mother liquor which may have escaped the previous washing and precipitates any gypsum which may have remained, so that the dried product analyzes 99.823 per cent Na Cl. The small amount of impurities which does remain consists of sulphates of calcium, magnesium and sodium and chlorides of calcium and magnesium.

STACKING AND SHIPPING

The elevator described dumps the salt to a semi-circular trough with bottom gates carried on a trestle. A screw works in this trough so that by opening the proper gate the salt may be discharged at any desired point to the stock piles shown in Fig. 3.

The salt is thus stacked in piles 50 ft. high and allowed to dry in the air, by which process the moisture content is reduced to $1\frac{1}{2}$ to 3 per cent. Under the platform supporting the stock piles are horizontal screw conveyors so that, as the salt is picked down by hand, it is carried along to the boot of a scraper elevator. This elevator runs at an angle of 45 deg. and delivers to a short screw, which feeds a 4 x 12 ft. hexagonal trommel with a $\frac{3}{8}$ in. wire screen.

Overize and undersize of the trommel run to spouts and thence to 50 lb. sacks, which are automatically weighed, sewed and tossed to a short belt conveyor, by which they are delivered either to the shipping platform or boxcars. Elevating, sacking and weighing machinery are mounted on trucks on a 6 ft. track running parallel to the stock pile, so that they may always be convenient to that part of the pile which is being shipped.

The annual output of the plant is from 30,000 to 40,000 tons.

POSSIBLE BY-PRODUCTS

The bitter water, the drainings of the crystallizing pond, which is now going to waste, contains compounds from which valuable by-products could be obtained.

An analysis of this water shows total solids of 28.86 per cent, as follows:

Mg Cl	9.10
Mg SO ₄	5.60
Na Cl	12.06
K, Br, etc.	2.10

Sp. G.=1.2608. Weight per gallon=10.51 lbs.

The magnesium chloride is the most important constituent of the bitter water, forming as it does 31.5 per cent of the total solids. Prior to the floods mentioned the Magnesium Products Company operated a plant adjacent to the salt ponds and bought the bitter water on contract. Its principal products were magnesium chloride and magnesium sulphate (epsom salts). Unfortunately this plant was almost directly in line with the flood and was a total wreck. It has not been rebuilt and the Western Salt Company is now desirous of making another contract of a similar nature by which this waste may be utilized.

San Francisco, Cal.

Chemical and Physical Research in Norway.—The "Norsk hydroelektrisk Kvaestof aktieselskab" has set aside 100,000 kr. to be transferred to the Nansen fund trustees, Christiania, Norway, for the promotion of chemical and physical research. Inasmuch as the founder of this company, Sam Eyde, celebrated his fiftieth birthday on Oct. 29, 1916, the company desires that this fund shall be designated as "The Sam Eyde fund for the promotion of chemical and physical research."

The Analysis of Nickel Chromium Alloys

By Emil D. Koepping

The sample, if a fair-sized piece, is prepared for analysis by drilling in the usual manner. If it is in the form of wire it should first be cleaned with emery cloth and then wiped with a clean cloth saturated with alcohol. The wire is then cut into very short lengths.

SILICON

Weigh out 2 g. of the sample and transfer to a casserole. Add 10 c.c. of water, and 25 c.c. of a mixture of 1 part of nitric acid and 4 parts of hydrochloric acid. Place on the hot plate and heat until solution is complete. When completely dissolved remove from the hot plate and add half a gram of potassium chlorate. Replace on the hot plate and evaporate to dryness. Cool; take up in 30 c.c. of hydrochloric acid and again evaporate to dryness and bake. Cool; take up with 10 c.c. of hydrochloric acid and 100 c.c. of water. Boil for 5 minutes. Filter through an ashless filter paper using suction. Catch the filtrate in a clean beaker. Wash alternately with hot water and hot 3 per cent hydrochloric acid several times, then with water alone several times. Suck dry. Place the filter in a platinum crucible and burn off the paper over a low flame. Ignite strongly, using a blast lamp or Meker burner. Cool in a desiccator and weigh. Treat the residue with a drop or two of nitric acid and about 1 c.c. of hydrofluoric acid. Evaporate the acids on the hot plate or over a very low flame. Ignite strongly, cool and weigh as before. The loss in weight is silica. From this calculate the silicon.

NICKEL

The filtrate from the silicon determination is diluted to one liter in a volumetric flask. A 100 c.c. portion (≈ 0.2 g.) is measured off, using either a volumetric flask or an accurate pipette, and transferred to a 600 c.c. beaker and diluted to 300 c.c. About 10 g. of powdered citric acid is then added to the solution and dissolved. Neutralize the solution with ammonia and then acidify with 1 c.c. of acetic acid. Heat to boiling and add 1 g. of dimethylglyoxime which has been dissolved in about 100 c.c. of alcohol by warming. Then add ammonia dropwise while stirring until the solution smells slightly of ammonia. The nickel will then have been precipitated as nickel dimethylglyoxime. Allow the solution to stand on a cooler portion of the hot plate for about 10 minutes, stirring occasionally. Filter the hot solution through a Gooch crucible which has been dried at 110-120 deg. C. and weighed. Wash with hot water and dry for 45 minutes at 110-120 deg. C.; cool and weigh. The nickel dimethylglyoxime is red and crystalline. It contains no water of crystallization and sublimes at 250 deg. C. without decomposition. Consequently it should not be heated too long or too hot. It contains 20.316 per cent of nickel.

If a duplicate determination of the nickel is desired, weigh out 0.2 g. of the sample. Place in a 600 c.c. beaker and dissolve in 10 c.c. of hydrochloric acid and 10 c.c. of water, add 5 c.c. of nitric acid and 10 c.c. of sulfuric acid. Evaporate over a free flame until the solution smells sweet. Cool, dilute to 100 c.c. and filter off the silica. Dilute the filtrate to 300 c.c. and proceed as before.

CHROMIUM

Measure off 200 c.c. (≈ 0.4 g.) of the filtrate from the silicon determination, transfer to a 600 c.c. beaker, add 10 c.c. of sulfuric acid and evaporate until the solution smells sweet. Cool, dilute with a little water and evaporate again to be sure that all hydrochloric acid has been removed. Cool; dilute with 50 c.c. of water;

add 60 c.c. of dilute nitric acid (sp. gr. 1.2, 3 parts of conc. nitric acid to 4 parts of water) and boil two minutes. Then dilute with 200 c.c. of hot water and when boiling add a strong permanganate solution a little at a time until a slight precipitate of manganese dioxide is formed that does not dissolve on boiling. The solution should have a reddish color from undecomposed permanganate after 5 minutes boiling. Decompose the excess permanganate with a little manganese sulfate solution and cool. Filter through an asbestos matt and wash with dilute sulfuric acid (one part conc. acid to three parts of water). The volume of the solution, which is now ready for titration, should be about 350 c.c. Add a measured excess of N/10 ferrous sulfate solution and titrate back with N/10 permanganate solution with constant stirring until a pink tint is obtained which persists for at least 1 minute.

The permanganate solution should be standardized against sodium oxalate (Sørensen's) in the usual manner. The iron value so obtained multiplied by 0.3103 gives the chromium value of the permanganate. The ferrous sulfate should then be titrated with permanganate in an acid solution which has been treated just as if it were a sample. Finally the ferrous sulfate should be titrated with permanganate in a solution containing about the same amount of nickel and iron as the sample, but free from chromium, and which has been treated exactly as if it were a sample. The amount of permanganate necessary to produce the pink tint over and above that required in the titration when the acids alone were present is to be subtracted from the permanganate used.

If a duplicate determination is desired, dissolve 0.4 g. of the sample in 10 c.c. of hydrochloric acid and 10 c.c. of water. Add 10 c.c. of sulfuric acid and evaporate until sweet as before and proceed as above.

MANGANESE

Weigh out 1 g. of the sample and transfer to a beaker. Dissolve in 20 c.c. of hydrochloric acid, 5 c.c. of nitric acid and 20 c.c. of water. When solution is complete cool somewhat and add 10 c.c. of sulfuric acid. Evaporate until the solution smells sweet. Cool and dilute with water. Add strong sodium hydroxide solution until a permanent precipitate appears. Dissolve the precipitate with a few drops of sulfuric acid and cool to room temperature. Transfer the solution to a 500 c.c. volumetric flask and add zinc sulfate solution equivalent to 10 g. of the crystallized sulfate and 1 g. of zinc oxide. Dilute to the mark and shake. Allow to settle and decant 250 c.c. (= 0.5 g.) through a dry filter catching the filtrate in a volumetric flask. Transfer to a beaker and heat to boiling. Titrate slowly with N/10 permanganate solution with constant stirring until the pink color of the permanganate appears in the solution. Then add 1 c.c. of glacial acetic acid and boil. The pink color will be discharged owing, apparently, to the liberation of absorbed manganous salt from the precipitate, which now becomes flocculent and settles. The solution is again titrated until the pink color is restored. The total volume of permanganate used is taken as that required to react with the manganese present.

If the sample proves to be low in manganese a large enough sample should be taken so that at least 5 or 6 mg. of manganese are present in the liquid which is to be titrated.

IRON

Measure off 100 c.c. (= 0.2 g.; or any other suitable aliquot part which does not represent over 0.05 g. Fe) of the filtrate from the silicon determination and neutralize with sodium carbonate solution until a permanent precipitate forms. Redissolve the precipitate with 1-1

hydrochloric acid, adding a drop at a time and allowing each drop two or three minutes to act. When clear add 1 g. of ammonium acetate and dilute to 300 c.c. Heat to boiling and boil vigorously for ten minutes. Allow to settle and filter, washing once with hot water. Redissolve the precipitate in hot 1-1 hydrochloric acid, neutralize with sodium carbonate and repeat the basic acetate separation as above. Dissolve the precipitate from the filter in hot 1-1 hydrochloric acid and wash the filter well with hot water. Neutralize the solution with potassium hydroxide solution and add an excess. Dilute the solution to 200 c.c. and boil 5 minutes. Set on a cooler part of the hot plate to settle. Filter into a clean beaker and wash the precipitate with hot water. Set the filtrate aside for the determination of aluminum. Dissolve the precipitate of ferric hydroxide from the filter in hot 1-1 hydrochloric acid and wash the filter several times with hot water. Evaporate the solution to small bulk (about 5 c.c.). From a dropping bottle add stannous chloride solution (prepared by dissolving 250 g. of stannous chloride in 100 c.c. of concentrated hydrochloric acid and diluting to one liter) until the solution becomes colorless. Dilute with 100 c.c. of cold distilled water and pour into 400 c.c. of water containing 20 c.c. of a saturated solution of pure mercuric chloride in water. A slight silky precipitate of mercurous chloride should form. 30 c.c. of "titrating" or "guard" solution are now added and the solution is titrated to the appearance of a pink color which permeates the entire solution and is permanent for 30 seconds.

The "guard" solution is prepared as follows: 67 g. of crystallized manganese sulfate are dissolved in 500 c.c. of water; 138 c.c. of syrupy phosphoric acid (sp. gr. 1.7) and 130 c.c. of concentrated sulfuric acid are then added, and the mixture is diluted to one liter.

ALUMINIUM

The caustic potash filtrate from the separation of iron and aluminium is acidified with hydrochloric acid. Add 15 c.c. of a saturated solution of sodium phosphate and then ammonia with constant stirring until a slight permanent precipitate forms. Now add 5 drops of hydrochloric acid. This should dissolve the precipitate and leave the solution clear. Then add with constant stirring 20 c.c. of a saturated solution of sodium thiosulfate. Cover the beaker and heat to boiling, and when boiling add 20 c.c. of a solution prepared by dissolving 100 g. of sodium acetate in 200 c.c. of acetic acid (sp. gr. 1.04) and diluting to 500 c.c. Boil the solution 10 minutes. Allow to settle, filter through an ashless paper and wash thoroughly with hot water. Place the filter and precipitate in a weighed porcelain crucible and dry. Ignite at a low heat until the paper has burned off and then ignite over the blast lamp or a Meker burner.

Cool in a dessicator and weigh as AlPO_4 . The precipitate after ignition should be white.

SULFUR

Fuse 2 g. of the sample with 15 g. of sodium peroxide in a nickel crucible. The heat should be applied very slowly. An alcohol lamp, gasoline, gas or electric heat should be used as the sulfur in ordinary gas is liable to vitiate the result. As soon as the fusion is liquid raise the heat for a few minutes and then allow to cool. Place the crucible on its side in a beaker and cover with a watch glass. Add about 30 c.c. of water and when the violent action is over remove the crucible and wash it. Dilute the solution to 200 c.c. and filter from it the insoluble ferric oxide, nickel oxide, etc., and wash with water containing a little sodium carbonate. Acidify the

filtrate with hydrochloric acid and evaporate to dryness in a casserole and bake. Cool; add 20 c.c. of hydrochloric acid and heat until all soluble salts dissolve. Dilute with hot water, filter, and wash with hot water. Neutralize the filtrate with ammonia and acidify with 1 c.c. of hydrochloric acid. Heat to boiling and add 10 c.c. of a boiling 10 per cent solution of barium chloride. Boil for a few minutes. Allow the solution to stand over night, preferably in a warm place, filter through a Gooch crucible which has been ignited, cooled and weighed, wash thoroughly, dry, ignite at a dull red for 10 minutes, cool and weigh. Calculate the barium sulfate to sulfur.

PHOSPHORUS

Fuse 2 g. of the sample with 15 g. of sodium peroxide in a nickel crucible. Dissolve the fusion in water as under "Sulfur." Dilute to 200 c.c. and filter. Wash with water containing a little sodium carbonate. Acidify the filtrate with nitric acid, heat to expel carbon dioxide, add a little ferric chloride solution, add ammonia until the solution is alkaline to litmus paper and then acidify with acetic acid. Boil for a few minutes, filter, wash the precipitated ferric phosphate and hydrate with hot water. Dissolve the precipitate in hot 1-1 hydrochloric acid and evaporate to dryness. Redissolve in 1 c.c. of hydrochloric acid, dilute and filter off the silica. Evaporate to small bulk, and drive off the hydrochloric acid with nitric acid. Transfer the nitric acid solution to a flask, add 5 g. of ammonium nitrate and dilute to 50 c.c. Heat to 80 deg. C. and add 50 c.c. of molybdic acid solution while rotating the solution in the flask. Shake for two or three minutes and allow to stand one hour. Filter and wash with ammonium nitrate solution (5 g. per liter). Dissolve the precipitate in 10 c.c. of dilute ammonia (8 per cent), add 5 g. of ammonium nitrate, dilute to 50 c.c., heat to 80 deg. C. and reprecipitate by adding 20 c.c. of nitric acid while rotating the solution as before. Agitate for a minute or two and allow to stand one hour. Filter and wash with ammonium nitrate water as before, or with water until neutral if the precipitate is to be titrated.

The phosphorus may now be determined in the "yellow precipitate" either volumetrically by dissolving in an excess of standard sodium hydroxide solution and titrating the excess with standard nitric acid using phenolphthalein as indicator or the "yellow precipitate" may be redissolved in ammonia and the phosphorus determined as follows: The solution is neutralized with nitric acid until the yellow precipitate formed dissolves only slowly on being mixed with the solution. 10 g. of ammonium chloride are then added and the solution is heated to boiling. 10 c.c. of magnesia solution are then added dropwise followed by one-third the solution's volume of 10 per cent ammonia. After standing two or three hours the solution is filtered through a Gooch crucible, which has been ignited and weighed, and the precipitate is washed with 2 per cent ammonia water. The crucible and precipitate is dried, placed inside a larger porcelain crucible and heated gradually up to a bright red. The magnesium pyrophosphate thus formed should be white or very nearly so. The crucible is cooled in a desiccator and weighed. The magnesium pyrophosphate found is calculated to phosphorus.

CARBON

Carbon is best determined by burning a sample of the drillings, after mixing with an equal quantity of red lead, the "blank" of which is known, in oxygen and absorbing and weighing the carbon dioxide formed.

Lockport, N. Y.

Plastic Cements*

By J. B. Barnitt

A working knowledge of the correct mixtures and proper application of plastic cements is deemed so essential to successful chemical engineering operations that an effort has been made to collect and classify a few of the more valuable formulæ and suggestions gained both from experience and current literature.

It is to be understood that plastic cements cover that range of adhesives which are used to secure joints and connections between like or unlike material and which are of more or less permanent character. Physically speaking, plastic cements consist of a vehicle in which are suspended or dissolved solids of such nature that they are resistant to the gases and liquids coming in contact with them. In some cases the constituents of the cement react with each other or with the surfaces to which they are applied, thus forming a more strongly adhering mass. The prime object being in all instances to effect a joint of maximum strength, and in nearly all cases gas tight, a few general instructions on the application of plastic cements are first given. It is, of course, rather an exaggeration to base the success or failure of a process upon the choice of proper cements used in the mechanical construction of apparatus necessary, but it must be conceded that great annoyance has been experienced in manufacturing operations wherein unsuitable compounds were used. This is especially true with such corrosive gases as hydrochloric, chlorine, nitric, sulfuric and sulfurous, bromine, hydrogen sulfide, etc., from which considerable damage to property and loss of life have frequently resulted.

One of the principal precautions to be observed in the application of a cement is the condition of the material to be joined. All connections should be properly fitted together with flanges or exposed flat surfaces as nearly coincident as possible. The cement should never be depended upon to do what the pipes or other portions of the apparatus should do. Its function is to cement or seal and nothing more. In most cases one part of the fitting should overlap the other so as to make a small amount of the cement effective. Cement for a joint of this type should be of a nature that may be quickly applied, that is effective while in place and easily removed when desired. An excess of cement should always be avoided to prevent shrinkage, cracks and leaks.

The general methods of plastic cement application are varied to suit special cases as follows:

(a) Heating the composition to make it plastic until firmly fixed in place.

(b) Heat applied to the surface to be cemented.

(c) Application of the cement with water or a volatile solvent, depending upon the evaporation of the solvent for drying or setting.

(d) Moistening the surfaces to be cemented with water, oil, etc. (The vehicle of the cement itself.)

(e) Application of the cement in workable condition, setting taking place by: (1) chemical reaction, (2) hydration, (3) oxidation.

The application of the following materials as plastic cements is noted: (1) plaster of paris; (2) hydraulic cement; (3) clay; (4) lime; (5) asphalt or pitch; (6) rosin; (7) rubber; (8) linseed oil; (9) casein and albumen; (10) silicate of soda and oxychloride cement; (11) flour and starch; (12) miscellaneous materials.

(1) PLASTER OF PARIS

Plaster of paris is often used alone as a paste for joints on gas and wood distillation retorts and similar

places where rapidity of setting is a requisite. In order to impart strength, a fibrous material such as asbestos is often mixed with it. Shavings, straw, hair and cloth are frequently used as binders, when a high temperature is not required, while stone, glass and various mineral substances are used as fillers. The following cements are particularly suitable for oil vapors and hydrocarbon gases:

- (a) Plaster and water.
- (b) Wet plaster and asbestos.
- (c) Wet plaster and straw.
- (d) Wet plaster and plush trimmings.
- (e) Wet plaster and hair.
- (f) Wet plaster and brokenstone.

(2) HYDRAULIC CEMENT

Cement is used either alone or with sand, asbestos, etc., and is especially resistant to nitric acid. When used with rosin or sulfur it is employed as a filler rather than for any powers of setting by hydration:

- (a) Cement alone.
- (b) Cement and asbestos.
- (c) Cement and sand.

(3) CLAY

This frequently enters into the composition of plastic cement as a filler. The finely divided condition of the material gives body to a liquid such as linseed oil which, unless stiffened, would be pervious to a gas, the clay being inert.

- (a) Clay and linseed oil is suitable for steam.
- (b) Clay, linseed oil and fire clay for chlorine gas.
- (c) Clay and molasses for oil vapors.

(4) LIME

Caustic lime and linseed oil mixtures are used as a putty. Chalk or china clay frequently replace part of the lime, but enough lime should remain to maintain the caustic property necessary to the formation of a certain amount of lime soap. Silicate and casein compositions also contain lime:

- (a) Lime and boiled linseed oil to a stiff mass.
- (b) Lime, clay, etc., and boiled linseed oil to a stiff mass.

(5) ASPHALT AND PITCH

Asphalt and pitch are used interchangeably in plastic cements, pitch making the stronger binder. Tar is of less value on account of the light oils and water contained in it. Asphalt in benzol is useful as an adhesive for uniting glass for photographic and microscopical uses, also for coating wood, concrete, brick work, steel, etc., where the melted asphalt would be too thick to apply readily. Benzol is the cheapest and most satisfactory solvent. For waterproofing, melted asphalt with a small amount of paraffin added, and in particular cases boiled oil, is used:

- (a) Refined lake asphalt.
- (b) Asphalt, 4 parts; paraffine, 1 part.
- (c) Asphalt, 10 parts; paraffine, 2 parts; boiled oil, 1 part.

Any of the above may be thinned with hot benzol or toluol.

- (d) Pitch, 8 parts; rosin, 6 parts; wax, 1 part; plaster, $\frac{1}{4}$ to $\frac{1}{2}$ part.

- (e) Pitch, 8 parts; rosin, 7 parts; sulfur, 2 parts; stonepowder, 1 part.

Compositions (d) and (e) are used to unite slate slabs and stoneware for engineering and chemical purposes. Various rosin and pitch mixtures are also used, the proportions determined by the consistency desired. Sulfur chemically prevents the formation of cracks

while stonepowder acts in like manner mechanically. If acid vapors or corrosive gases come in contact with the cement, limestone should not be the powder used, otherwise it is best. Wax prevents the composition from becoming brittle.

Plastic cements for calking must be both tough and elastic and have the added property of expanding and contracting with the joint to which they are applied:

- (f) Pitch, 3 parts; shellac, 2 parts; pure crude rubber, 1 part.

- (g) Pitch, 1 part; shellac, 1 part; rubber substitute, 1 part.

(f) and (g) are mixed by melting over a burner.

(6) ROSIN, SHELLAC AND WAX

A strong stone cement having little body and applied in layers.

- (a) Rosin, 8 parts; wax, 1 part; turpentine, 1 part. For nitric and hydrochloric acid vapors.

- (b) Rosin, 1 part; sulfur, 1 part; fire-clay, 2 parts. Sulfur gives great hardness and permanency in rosin cements.

Good waterproofing cements are:

- (c) Rosin, 1 part; wax, 1 part; powdered stone, 2 parts.

- (d) Shellac, 5 parts; wax, 1 part; turpentine, 1 part; chalk, 8 to 10 parts.

For a soft airtight paste for ground glass surfaces:

- (e) Wax, 1 part; vaseline, 1 part.

A strong cement without body for metals (not copper), porcelain and glass.

- (f) Powdered shellac, 1 part; ammonia water, 10 parts. Allow to stand until solution is effected.

(7) RUBBER

Because of its toughness, elasticity and resistance to alterative influences, rubber is a very useful cement.

As a leather cement:

- (a) Asphalt, 1 part; rosin, 1 part; gutta percha, 4 parts; carbon disulfide, 20 parts.

As a resistant to acid vapors:

- (b) Rubber, 1 part; linseed oil, 2 parts; fireclay, 3 parts.

A plain rubber cement:

- (c) Cut crude rubber in small pieces and then add carbon disulfide or benzol, allowing the rubber to dissolve.

Corks and wood are made impervious to water by soaking them in the above solution.

(8) LINSEED OIL

Linseed oil is one of the most generally useful materials for cementing purposes.

For aqueous vapors:

- (a) China clay and linseed oil.
- (b) Lime and linseed oil, forming the well known putty.

- (c) Red or white lead and linseed oil.

The above mixtures become very strong when set and are best diluted with powdered glass, clay or graphite.

- (d) Oxide of iron and linseed oil.

(9) CASEIN, ALBUMEN AND GLUE

Cements of this nature, if properly made, become very tough and tenacious, are resistant to moderate heat and oil vapors but not acid fumes.

- (a) Finely powdered casein, 12 parts; fresh slaked lime, 50 parts; fine sand, 50 parts, and enough water to make a thick mass.

A strong cement for ground unions standing a moderate heat:

- (b) Casein in fine powder, 1 part; rubbed with silicate of soda, 3 parts.

(c) White of egg made into a paste with slaked lime. This should be used immediately after being made up.

A composition for soaking corks, wood packing, etc., to render impervious to oil vapors:

(d) Gelatine, 2 parts; glycerine, 1 part; water, 6 parts.

(10) SILICATE AND OXYCHLORIDE CEMENTS

For oil vapors standing highest heat:

(a) Paste of sodium silicate and asbestos.

For gaskets for super-heated steam retorts, furnaces, etc.:

(b) Sodium silicate and glass.

(c) Sodium silicate, 50 parts; asbestos, 15 parts; slaked lime, 10 parts.

A metal cement:

(d) Sodium silicate, 1 part; oxides of zinc, lead, or iron, singly or mixed, 1 part.

(e) Zinc oxide, 2 parts; zinc chloride, 1 part; water to make a paste.

(f) Magnesium oxide, 2 parts; magnesium chloride, 1 part; water to make a paste.

(11) FLOUR AND STARCH

(a) Flaxseed makes a very tough cement but does not withstand water.

(b) Flour and molasses to a stiff paste.

A permanent cement for ordinary temperatures impervious but attacked by condensing steam and nitric vapors.

(c) Stiff flour paste and concentrated zinc chloride solution.

As a core compound:

(d) Dextrine and fine sand.

(12) MISCELLANEOUS

For insertion of glass tubes in brass or iron:

(a) Litharge and glycerine mixed to a stiff paste.

For high heat:

(b) Alumina, 1 part; sand, 4 parts; slaked lime, 1 part; borax, $\frac{1}{2}$ part, water.

Core compounds:

(a) Dextrine, 1 part; sand, 10 parts; water to form a thick paste.

(b) Anthracite coal powdered with molasses added to thick paste.

(c) Rosin, partly saponified by soda lye, 1 part; flour, 2 parts; sand, 4 parts; with water as a diluent.

(d) Powdered glue, 1 part; flour, 4 parts; sand, 6 parts, water.

As a coating for glass ware to protect from injury by direct flame:

(a) A mixture of fire clay and plumbago made into a paste with water.

For retorts:

(a) Fine flour and lime, 1 part; potters earth $\frac{1}{2}$ part; make a moist paste with white of egg well beaten with a little water.

For melting pots:

(b) Sift brick dust and mix with equal quantity of red lead; rub together with boiled linseed oil, which has been mixed with sand to a stiffness of cement. In covering dishes apply the paste first then apply sand and heat.

(c) Put freshly slaked lime with concentrated solution of borax, apply with a stiff brush and allow to dry. Upon heating a fused glaze is obtained.

For large pots:

(d) Litharge, 6 parts; fresh burnt lime, 4 parts; white bole, 2 parts; and mix with cold linseed oil.

Laurel Hill Laboratory,
General Chemical Co.

Suggested College Course on the Human Side of Engineering.—In our issue of Feb. 1 (page 123) we referred editorially to the splendid work carried out during the past nine or ten years by the International Committee of Young Men's Christian Associations (Industrial Department). They have now enlisted 4500 college men from 250 colleges who are reaching each week 100,000 working men and boys in voluntary service, teaching English to foreigners, instruction classes of American workmen, etc. A further outcome of this work is a suggested college course on the human side of engineering which has been prepared with the help of leading professors, business men and social workers. It is arranged to cover 64 or preferably 96 class periods—four or eight months' work at the rate of two or three periods a week. There are twelve sections: the human factor in industry; the evolution of the individual worker in industry; industrial organization and the influence of the modern system on the worker; human factors in production (capital and labor, immigration, unionism, etc.); working, living and leisure conditions; the ethics of engineering and business; vocational guidance and the education of employees; cooperative organizations; legislation and public opinion on industrial questions; the progress of typical companies; intelligent dealing with employees; the engineer's responsibility for service. A copy of a full outline of this suggested human engineering course will be sent on request by Mr. Fred. H. Rindge, Jr., secretary, Industrial Service Movement, 124 East Twenty-eighth Street, New York City.

Annual Meeting of Institute of Metals.—The Institute of Metals (London) will hold its annual meeting in the rooms of the Chemical Society on Wednesday, March 21 and 22. A special feature of the meeting will be a general discussion on metal melting, which includes six papers on melting of non-ferrous metals by gas, coke, oil fuel, and electricity, and under various pressures. The following papers will be presented:

AT THE MEETING ON MARCH 21:

"The General Properties of Stampings and Chill Castings in Brass of Approximately 60/40 Composition." By Owen W. Ellis, B.Sc. (London).

"Machining Properties of Brass." By Owen W. Ellis, B.Sc. (London).

"Surface Tension and Cohesion in Metals and Alloys." By Sydney W. Smith, B.Sc., A.R.S.M. (London).

"Aluminum Production by Electrolysis: A Note on the Mechanism of the Reaction." By R. Seligman, Ph. Nat.D. (London).

"Annealing of Nickel Silver" (Part II). By F. C. Thompson, D.Met., B.Sc. (Sheffield) (subject to being completed in time).

AT THE MEETING ON MARCH 22 (GENERAL DISCUSSION ON METAL MELTING):

"Metal Melting as Practised at the Royal Mint." By W. J. Hocking (London).

"Coal Gas as a Fuel for the Melting of Non-ferrous Alloys." By G. B. Brook (Sheffield).

"High Pressure Gas Melting." By C. M. Walter, M.Sc. (Birmingham).

"Contribution to Metal Melting Discussion." By H. M. Thornton (London) and H. Hartley, M.Sc. (London).

"An Electric Resistance Furnace for Melting in Crucibles." By H. C. Greenwood, D.Sc. (London), and R. S. Hutton, D.Sc. (Sheffield).

"Ideals and Limitations in the Melting of Non-ferrous Metals." By Carl Hering (Pa., U.S.A.).

"Metal Melting in a Simple Crude Oil Furnace." By H. S. Primrose (Ipswich).

Hydroelectric Power and Electrochemistry and Electrometallurgy in France—II

By C. O. Mailloux, E.E., D.Sc.

Member of the American Industrial Commission to France

It is in connection with the electrochemical and electrometallurgical industries that the importance of low cost of electrical energy is fully realized. It is soon discovered here that the figures mentioned in the first article as being exceptionally low for the cost of electric current for operating motors to produce mechanical power in cities like Lyon and St. Etienne would not only be high, but would be quite prohibitive in the case of the electric power required for the operation of electric furnaces or for the operation of most electrometallurgical and electrochemical processes, especially those which require the production of heat by electrical means.

In the case of the electrical energy required for electrochemical and electrometallurgical purposes, it is necessary, in order to arrive at the most satisfactory solution—the one giving the lowest cost—to consider separately the cost of producing power at the power station and the cost of transmitting it to distant points, and of distributing it at those points. The cost of transmitting and distributing power is often much higher than the cost of generating it. An outlay of capital is required to set up transmission lines, substations, transformers, distribution systems, etc. This means overhead charges for interest, taxes, etc., and maintenance charges for attendance, repairs, supplies, etc. Moreover, a certain loss of energy is inevitable in the transmission and distribution system. It must be remembered that the power "lost" between the power station and the point at which the useful power is delivered is just as much a part of the total power generated as the "useful" power itself. It is the "useful" power, however, that must cover the cost of both kinds of power. Hence, the greater the percentage of power that is lost in transmission lines and distribution systems the greater the cost of the "useful" power becomes. This makes it obvious that for very cheap power the losses between the point where it is generated and the point where it is utilized must be reduced to a minimum.

The capital outlay, the overhead charges, the loss of energy can all be avoided by utilizing the electric current at the point where it is generated. As a general rule, the nearer the location of the works to the power plant the lower the cost of power will be. Frequently there is an incidental advantage in locating the works near the power plant, namely, that the ground, the buildings and the facilities required for the works cost less. To offset these advantages there may be objections or disadvantages incidental to the location of the works near the power station, the principal one being difficulty and cost of transportation to the works of the raw material and supplies necessary for the product to be made, and also the cost and delay of transportation of the product itself from the works to the market.

In some cases there is every advantage and no disadvantage in locating the works near the power station. In other cases, for various reasons, the works may have to be located at some distance from the power station. The important point to be noted is that there is always a limit to that distance; there is a distance beyond which the power in question is not desirable for the purpose in view, for the very reason that the cost of the power delivered at the point of consumption becomes too high. The point of prohibitive cost differs according to the purpose and the process for which electrical energy is needed. In the case of metallurgical or chemical processes involving the use of electric furnaces or

depending upon the heating effects produced by electric currents, the cost of electric current ought to be brought down to about \$12 per electrical horsepower per year (which is equivalent to about \$16 per kilowatt-year), and it is highly desirable that the cost should be as much below that figure as possible.

It is said that in the case of some of the large water powers in Norway, where the cost of development per horsepower was very low, the cost of power at the power station is as low as \$5 or \$6 per horsepower-year. These are exceptionally favorable cases. A power cost of \$10 to \$12 per horsepower-year would be considered low; above that price it becomes less satisfactory, and it may be too high for many purposes. The price charged at Niagara Falls, \$15 per horsepower-year (equivalent to \$20 per kilowatt-year), is considered high for many electrochemical and electrometallurgical purposes. Some of the power consumers there have found that it paid them to provide steam power for a part of their load to take care of their own "peaks" in power consumption, and thus maintain the Niagara power used by them as constant as possible. The reason is that the charge made for Niagara power increases with a decrease in the evenness of the load, as measured by what is termed the "load factor." It is significant that in these cases the consumer finds Niagara power too expensive for the whole of his requirements. This was not the case when the "base prices" for Niagara power were lower.

A cost of \$16 per kilowatt-year (8760 hours) corresponds to very nearly one-fifth of a cent per kilowatt-hour. This justifies the statement previously made that a cost of 1 cent per kilowatt-hour would be prohibitively high for electrochemical work.

To obtain the low electrical power costs which are so desirable for electrochemical purposes, the cost of developing the water power must be very low per horsepower developed. This condition is usually favored by power sites of high head, in favorable locations permitting development with dams of small size and of low cost. It is often said that the concerns engaging in electrochemical and electrometallurgical operations requiring large amounts of electrical energy cannot afford to buy, but must themselves produce their electric current supply. The reason for this statement is that the cost of current supply obtained from a company that makes a business of furnishing electric power must include a fair profit for that company, whereas when the power is produced by the concern which needs it the profit is obtained from the product manufactured, and not from the power, which is generally reckoned at the cost of its production. It is for this reason that, with few, if any, exceptions, in the "white coal" region, the water powers supplying electrical energy to electrochemical and electrometallurgical companies belong to those companies, and were developed by them for their own purposes.

If electric power must be very cheap in order to be useful for electrochemical and electrometallurgical purposes, then the fact that so much power is used for these purposes in the "white coal" region of France may be regarded as fairly conclusive evidence of the low cost of production of that power. From the official figures which have already been given for the different uses made of the water power in the "white coal" region, it is seen that the power used in electrometallurgical works (225,000 hp.) and that used in electrochemical works (147,000 hp.) together make up 402,000 hp., or 54.5 per cent of the total power in that region. It may be fairly presumed from the physical characteristics of the white coal region that the undeveloped power in that region will not prove more expensive than that which is already

in use. Indeed, as the result of the extensive experience gained in connection with the construction and operation of the existing hydroelectric power plants, it may reasonably be expected that the cost of development and of operation, and, consequently, the cost of the "useful" power, from new power developments, can be further reduced. Moreover, the possibilities of cheap power in the region of the Pyrenees are also very good. It is quite conceivable, therefore, that there may be available in France an amount of very cheap hydroelectric power suitable and economical for electrochemical and electrometallurgical work that would, in time, bring the aggregate of such work to a point requiring as much as 1,500,000 or even 2,000,000 hp. When that time arrives, France will be occupying a position of highest importance in these industries. It certainly seems to have important odds in its favor in the race for leadership in this field. The good showing already made in the space of a few years by these industries, as shown by the very large total amount of power used for their kind of work, is a good sign that the great possibilities of these industries in France are understood and appreciated there, and that further important developments may be looked for in rapid succession.

Electrochemistry

The American Industrial Commission to France saw a large number of electrochemical and electrometallurgical plants, and it visited a few of them in the "white coal" region. One of these establishments belonged to the Société d'Electrochimie, which operates six plants, located at different places in France. At the establishment visited, which is near Rieupeux (Isère), the power utilized was about 6000 hp. The products made there included the rarer metals, aluminium, magnesium, sodium, calcium, all produced as pure metals, and sodium peroxide, calcium hydride, compressed oxygen, and various other chemical substances produced as chemical products.

This company was originally formed (in 1889) with the object of manufacturing chlorates of potassium and sodium by electrolysis. It played an important part in the pioneer days of the electrochemical industry in France. Besides developing the chlorate industry, it introduced in France the manufacture of metallic sodium and of sodium peroxide, the latter being a substance of great utility for bleaching vegetable fibrous materials, such as flax, cotton, ramie, etc.; it also introduced the manufacture of metallic calcium and of calcium hydride, the substance used for generating hydrogen gas in large quantities for inflating balloons. (One kilogram of this substance, when placed in water, will decompose enough water to set free over 1 cubic meter of hydrogen gas.)

The company also manufactures at some of its other works cyanide of potassium and of sodium, and various other chemicals used in the arts.

The applications which have been made of electrochemical processes in France include the production of a great variety of substances which may be classed into four groups:

Group 1—Calcium carbide.

Group 2—Nitrogen products, including nitrates, nitric acid, nitride of aluminium, and cyanamid of calcium.

Group 3—Chlorine and its compounds—the hypochlorites, chlorides and chlorates.

Group 4—Miscellaneous products; sodium, potassium, calcium, magnesium, and other rare metals; hydrogen and oxygen; carborundum; secondary products, etc.

Calcium Carbide.—It is well known that the calcium-carbide industry proved a serious disappointment many

years ago. The demand for that material did not grow as fast as was anticipated, and in consequence a condition of overproduction was reached all over the world, which forced many concerns to devote attention to other specialties and to find other work for a part or the whole of their plants.

In 1910, while the aggregate production capacity of seventy plants located in nine European countries, also in Canada and in the United States, was over 360,000 tons per annum, the total demand and production fell under 250,000 tons. In that year there were about twenty electrochemical plants which produced calcium carbide in France, the total quantity made being 30,000 tons. In 1913 there were in France sixteen plants which produced calcium carbide, the total quantity made being 45,000 tons, out of an aggregate production for the entire world of 339,000 tons (see Table V). This increase in consumption was not due so much to increasing use of acetylene gas as an illuminant; it was due, mainly, to two other causes: first, the development of the flame method of cutting and welding metals, sometimes referred to as the "acetylene-gas method" of autogenous welding; second, the increase in production of "cyanamid," a substance which is made from calcium carbide. The consumption from these directions is likely to increase.

Nitrogenous Products.—Electric current is used for making these products in two ways: first, by processes of "direct fixation" of nitrogen from the air; second, by processes of "indirect fixation," which involve the prior production of substances that are chemically adapted and can be made suitable for absorbing nitrogen. The first method, which depends upon the effect of electric arc discharges through atmospheric air in inclosed spaces leads to the direct production of nitric acid, from which nitrates may afterward be prepared. It is interesting to note here that this method was first put in operation some fifteen or sixteen years ago at Niagara Falls by an American electrochemist, Mr. C. S. Bradley.

The second method arrives at the fixation of nitrogen in a more roundabout manner and by distinct steps. The first step is the preparation of a substance capable of absorbing nitrogen; the second step is the transformation of this substance into a nitrogenous compound; the third step is the production from that compound of nitrogenous products of the kinds desired. The best known example of the second method is the so-called cyanamid process. In this case the first step is the production of calcium carbide in the electric furnace. The second step is the transformation of calcium carbide into calcium cyanamide by heating powdered calcium carbide to a red heat, obtained from electric power, and then passing nitrogen through the mass, whereupon the following chemical reaction takes place:

$$\text{CaC}_2 + 2\text{N} = \text{CaCN}_2 + \text{C}$$

(i.e., calcium carbide + nitrogen = calcium cyanamid + free carbon).

The third step consists in obtaining ammonia, a nitrogenous substance, from the cyanamid of calcium by a very simple process, which depends on the fact that when brought in contact with steam, calcium cyanamid decomposes into carbonate of lime and ammonia in the manner indicated by the following chemical equation:

$$\text{CaCN}_2 + 3\text{H}_2\text{O} = \text{CaCO}_3 + 2\text{NH}_3$$

(i.e., calcium cyanamid + water = lime carbonate + ammonia).

This chemical property accounts for the action of cyanamid as a fertilizer. When placed in the ground the moisture of the soil causes ammonia to be set free, as in ordinary ammoniacal fertilizers.

The fourth step consists in making nitric acid and nitrates from the ammonia obtained by the process just mentioned.

The enormous field available for the production of artificial nitrates is shown by the fact that the consumption of natural mineral nitrates, which, as is well known, come practically altogether from the enormous nitrate beds in Peru and Chile, exceeds 2,000,000 tons per year in times of peace.

The largest plants for producing nitric acid and nitrates by direct fixation are located in Norway. The Norwegian Nitrogen Company began operations at Notodden, Norway, in 1905. In 1907 the success of this company led to the formation of a new company, with the object of increasing greatly the output, by developing and utilizing additional water power. The power developed up to the present time exceeds 350,000 hp., and it will eventually attain 500,000 hp. The output capacity, at present over 200,000 tons of nitrate per annum, will, in time, attain or exceed 300,000 tons. Even this large output, however, is small in comparison with the aggregate world consumption for times of peace just mentioned, which is enormously increased in times of war, because no explosive can be manufactured without nitric acid.

The synthetic or artificial nitrates have a fertilizing action which is substantially equal to that of the natural (Chilean) nitrate. They are, however, more hygroscopic and deliquescent, and therefore a package of artificial nitrate, when once opened, will not "keep" as well as the natural nitrate, and must be used up more promptly. This peculiarity has proved a handicap to the artificial nitrate as a substitute for the natural nitrate by creating the suspicion that it was chemically inferior to it. The fear of slow development in the consumption of and demand for the artificial nitrate has reacted upon, if not halted, its production to some extent in France. This condition of uncertainty as to the market for synthetic nitrates, coupled with the fact that such a large quantity of these nitrates was being produced in Norway, led the French electrochemical interests to show a preference for the manufacture of nitric acid rather than nitrates, and to select the methods and arrange the processes accordingly.

A French company, known as the "Nitrogen Company," has been operating, since 1909, a direct-fixation nitrogen plant near Briançon, with nine double furnaces, each of 450 to 600-kw. capacity, oxidizing nitrogen from the air and producing a product which is then transformed into nitric acid of 36 deg. The power capacity of the plant is to be increased from 8000 to 20,000 hp., with a corresponding increase in the output of nitric acid. Negotiations were made, some years ago, with the owners of the process for the establishment of similar plants in other portions of France, notably in the Pyrenees. The war may have interfered with the carrying out of such projects.

The great objection to all direct-fixation processes thus far developed is the comparatively large amount of electrical energy required per unit of product obtained. For this reason attention has of late been given to other processes, including the cyanamid process of producing nitrogenous substances.

In 1910 a company known as the General Nitride Company was formed in France with the object of exploiting the Serpek process for the manufacture of an ammoniacal fertilizer, known as aluminium nitride. The process is based upon the use of the electric furnace to heat crude alumina in an atmosphere of nitrogen, by which nitride of aluminium is produced. By another step of the process this substance is subsequently decomposed into ammonia and pure alumina, which is the raw material required for making aluminium. In this process the manufacture of a nitrogenous fertilizer thus becomes closely related to the manufacture of alumi-

nium. The Serpek process, however, has not proved satisfactory, and from present indications, according to the investigations made by the National Research Council in this country in the last few months, it is not held in high favor, and is not considered likely to supersede either the "direct" fixation method or the other "indirect" methods, such as the calcium cyanamide method.

The total world production capacity of calcium cyanamide before the war did not exceed 100,000 tons per annum, of which France and the United States each produced about one-fifth. The production capacity has probably been increased considerably in the last two years.

Chlorine and Its Compounds.—Electrochemistry has furnished the simplest and cheapest methods for making chlorine and many of its compounds. It has stimulated the development of numerous industrial processes in which these chemical products find useful practical applications. There is a large and increasing demand for chlorinated products, which has manifested itself in a material increase in the amount of electric power utilized in this particular field of electrochemistry, in France as well as in America.

The electrolytic method of producing chlorine is theoretically quite simple; it consists merely in passing a continuous electrical current through a solution of sodium chloride (common salt), by which that substance is decomposed into its two constituent elements, namely, chlorine and sodium. The former is liberated at the positive pole, or anode, and escapes as a gas; the latter is liberated at the negative pole, or cathode, where it immediately decomposes the water that held the salt in solution to form caustic soda, which remains in solution, while the hydrogen thereby set free from the water is released and escapes into the atmosphere. In the practical application of this theoretically simple process there are various chemical and mechanical difficulties, resulting from the corrosive action of the chlorine produced, and the necessity of providing adequate means for its collection, and also of preventing its recombination with the soda that is also produced by the same electrolytic action. These difficulties have been overcome in various ways, and there are now numerous processes, some of them covered by patents, which have come into industrial use in many countries. A large industry has developed, which has affected the alkali industry in a radical and almost revolutionary manner, as will be pointed out later.

The chlorine produced by the electrolytic process is used as a source of supply of that substance in making hydrochloric acid and commercial chloride of lime, better known as "bleaching powder," and it has also become available as an article of commerce in liquid form at much lower cost than was formerly possible, with the consequence that a considerable demand for liquid chlorine has been developed. The abundance and cheapness of liquid chlorine have led to its use in making chlorides of various other metals and bases, such as chloride of ammonia, potassium, etc. Uses have been developed for many of these new chlorides, which were not utilized before because they were not obtainable in sufficient quantity.

Two important classes of chlorine compounds are obtainable by electrolysis, namely, hypochlorites and chlorates. The hypochlorites of sodium, potassium and magnesium are those best known and most frequently made. These compounds share in common certain very valuable chemical properties, which render them very useful, in form of "bleach liquors," for bleaching purposes, and more especially in the form of disinfectants for purifying contaminated and polluted waters. Hypochlorite of soda is prepared in greater quantity than the other hypochlorites, because the material from which it

is prepared (common salt) is more abundant and cheaper than the material required for the other hypochlorites.

The chlorates of potassium and sodium constitute one of the most important classes of compounds of chlorine, on account of the great demand for them in the arts. They are used in making matches, explosives, detonators, in dyeing, and for various other important purposes.

The production of chlorates was one of the early developments of electrochemistry in France. The first plant for making chlorates by electrolysis was established in France as early as 1886. Since that time three other plants have been established. Before the war France exported a considerable quantity (about 4000 tons per year) of chlorates.

Another chlorine compound which has been obtained by electrolysis is perchlorate of ammonium, a chemical product which is very stable and not readily exploded, but which, nevertheless, when mixed with organic bodies, produces explosives of great power, comparable with dynamite and chlorate explosives.

Another chlorine compound, carbon tetrachloride, is obtained as a by-product in some processes for making chlorine and caustic soda. Various other compounds of chlorine with carbon and with hydrogen, possessing remarkable chemical properties and susceptible of important industrial applications, such as the di-, tri-, tetra- and per-chlorides of ethylene, have come into existence and promise to be valuable by-products of the manufacture of chlorine, the chlorides and chlorates.

Miscellaneous Electrochemical Products.—The production of caustic soda, already mentioned as a circumstance attending the production of chlorine gas, when a solution of common salt is electrolyzed, is really an electrochemical achievement of greater importance and interest than the production of chlorine itself, because of its possible far-reaching effects on one of the oldest and most important chemical industries, that of "alkali manufacture." It happens that the electrolytic production of caustic soda comes into competition with the older methods of manufacturing that substance.

Electrolytic Soda and the Alkali Industry.—The alkali industry had its origin in France, as a real "war baby," in the beginning and early part of the last century. Even before the French Revolution the scarcity of alkali and the increasing demand for it in France had led to the search for methods of artificial "soda ash" and soda production. The need of such methods was made more urgent by the wars waged against France under the first republic, and those waged against or by France under Napoleon, because the supply of alkali previously derived from the other countries was then practically cut off altogether. It was necessity that prompted the many attempts made in France during that period to manufacture soda artificially from common salt.

Of the various methods proposed and tried, one—invented by a French chemist, Nicolas Leblanc—proved to be a satisfactory solution of the problem, and to be capable of giving useful industrial results, and in a remarkably short time it had, while conferring a great boon on France, revolutionized completely the world's production of soda. The Leblanc soda process was rapidly taken up in other countries, especially in England, where its development soon created the new and important industry of alkali manufacture, in which England rapidly took the foremost position, which it held practically undisputed until the beginning of this century.

In the last quarter of the nineteenth century, a new and better process, known as the "ammonia-soda" process, came into use, of which the best known example is

the well-known "Solvay" process, developed by Ernest Solvay, the Belgian chemist. The use of this process extended rapidly, until it served for producing the greater part of all the soda ash of commerce. England is now the only country where the Leblanc process is still in use to some extent.

It is practically against the Solvay process, therefore, that the electrolytic process for producing both chlorine and caustic soda must compete. This competition is of great interest to the electrochemical industry, not only in France, but also in America, where there are many electrolytic chlorine-and-soda plants. The Solvay process is also firmly established in both of these countries. The broad question is, to what extent the Solvay and Leblanc processes are likely to lose the ground now held by them as the principal source of production of the world's supply. The answer to this question depends upon the demand for chlorine and its compounds.

The Leblanc process was devised as a source of soda, and not as a source of chlorine. Indeed, the chlorine, which is set free, in the first stage of the process, as hydrochloric acid, in gaseous, anhydrous form, was at first allowed to escape in the air, and it was only when its corrosive action upon buildings, vegetation, etc., became intolerable that steps were taken to recover it and to utilize it. (In England the free liberation of this gas into the air was made the subject of anti-nuisance legislation.) The necessity of avoiding a nuisance was a blessing in disguise, for the development of methods for saving this gas, by condensation and otherwise, made the Leblanc process the principal source of supply of hydrochloric acid and of bleaching powder (chloride of lime).

While with the Leblanc process the operation of obtaining hydrochloric acid is relatively simple and cheap, the operation of obtaining pure chlorine gas, which necessitates the oxidation of the hydrogen contained in hydrochloric acid, is complicated and costly.

The ammonia-soda process is still less suitable than the Leblanc process as a source of chlorine.

The electrolytic chlorine-and-soda process is the only process that produces pure chlorine gas directly. Unfortunately, it cannot afford to throw the chlorine away, as the Leblanc process did, and still does to some extent, but must find a market for it in order to compete with the ammonia-soda process. That is why the future of the electrolytic process hinges upon the demand for chlorine. The difficulty is that the market for the alkali (soda) portion of the output is at present many times (possibly eight or more times) greater than the market for chlorine and its compounds.

The use of chlorine in the "chlorination" process of treating ores is an example of a relatively new use for liquid chlorine which may add materially to the demand for that substance. The increase in demand for hydrochloric acid will also benefit principally the electrolytic process, because the Leblanc process, now the principal source of that product, is on the wane, and may be discontinued altogether in due time. It is reasonable to expect, therefore, that the electrolytic process will get a constantly increasing share of the soda market; but it now seems hard to conceive of its being able to attain, let alone surpass, the ammonia-soda process as a purveyor of the world's demands for alkali.

Oxygen and Hydrogen.—The production of these two substances by electrolysis has been carried on in France since 1897. There are two plants in operation producing together about 300 cubic meters of oxygen and 600 cubic meters of hydrogen per day. There is an increasing demand for these gases for a variety of uses. The electrolytic process does not promise, however, to be able to compete successfully, so far as oxygen is con-

cerned, with the process of fractional distillation of liquid air, and it does not seem that there is much future for the electrolytic process.

The Société d'Electrochimie manufactures a product called "oxyliithe" and another called "hydrolithe," which when put in water liberate oxygen in one case and hydrogen in the other case. A kilogram of oxyliithe can generate 140 liters of oxygen and a kilogram of hydrolithe can generate 1000 liters of hydrogen. The commission witnessed experiments with these materials, but it did not obtain information as to their exact nature or their preparation.

Minor Products.—Small quantities are made by electrochemical means of various chemical products, including the following: Sodium-chromate, potassium-ferrocyanide, lead carbonate (white lead), minerals for colors (such as cadmium yellow and Paris blue), aniline colors, chloroform, iodoform, reduction products of mono-nitrobenzene, silicides of calcium, sodium, and potassium, baryta-salts, phosphorus, ozone.

Electrometallurgy

The figures given elsewhere for the total hydraulic power capacity installed in the region of the Alps show that almost 35 per cent of the aggregate power is utilized in electrometallurgical work. The only industry utilizing more hydroelectric power is that of "lighting and power," which utilizes 39.4 per cent of the whole amount.

In electrometallurgy—which is the art of producing and treating metals, metalloids and alloys by the aid of electricity—all processes carried out, and all chemical, physical and metallurgical effects produced, depend upon the action of energy on matter in one or both of two ways: first, by electrothermal action, i.e., the development of heat, usually, but not necessarily, intense, in the materials to be operated upon; second, by electrolytic action, i.e., a selective bodily transfer, in both directions, along the path of the electric current of certain chemical elements, so as to cause them either to accumulate and be deposited or else to be set free from the mass at the points thereof constituting the inlet and the outlet for the electric current.

While a continuous electric current can produce both kinds of action, the alternating current can only produce electrothermal action.

The processes of electrometallurgy are carried out in containers of two sorts: electric furnaces or ovens, and electrolytic cells or vats. The two kinds of actions (thermic and electrolytic) may occur in both sorts of containers, either independently or conjointly, according to circumstances and conditions.

Electric Furnace.—The principle of the electric furnace was discovered in 1809 by Sir Humphry Davy, who, using an electric arc in a crucible, obtained thermic and electrolytic actions by which he was able to produce for the first time many rare metals. In 1853 the first attempts were made in France and in England to construct electric furnaces for smelting ores. In 1878 Sir William Siemens, in England, patented a form of electric furnace, embodying many features of the modern electric furnace. In 1886, in France, Héroult put in operation the first electric furnace used for electrometallurgical work on a commercial scale. It was used at first for making aluminium. Later he developed a furnace for making steel. Both furnaces have given satisfactory results and are used in France and in America. Furnaces of various other types have been devised in many countries by many inventors. The principal types are the arc furnace, with alternating current; the "induction" single-phase furnace; the "induction" three-phase furnace, and various forms of "resistance" furnace.

Each type is supposed to have its advantages, and it may also have its disadvantages. From the electrothermal standpoint the claims made for any type may also be claimed for the others. These may be summarized as follows:

1. Ability to attain and maintain much higher temperatures than are possible in non-electric furnaces; instead of being limited to about 1800 deg. C. as in coke or gas furnaces, the temperature of an electric furnace may attain 3000 deg. C., or even 3500 deg. C.; in fact, the only limit is the melting temperature of the refractory linings of the furnace itself.

2. The heat is produced more efficiently and applied more effectually, because the work is done in a smaller space, the mass operated on is more compact, the working temperatures are higher, and the heat losses are smaller.

3. By reason of the higher temperatures, the melting and mingling of the various constituents of the charge and the fluidity of the mass are more perfect, and the chemical reactions sought to be obtained are produced more completely and effectively.

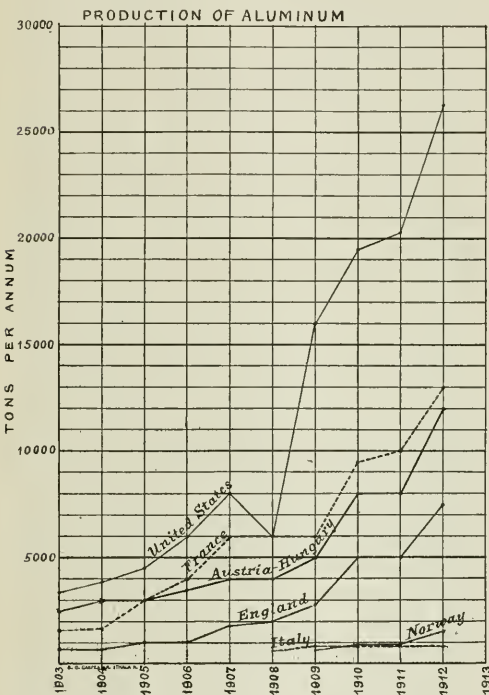
4. The atmosphere inside the furnace can be controlled much more perfectly than in a coke or gas furnace, because the absence of fuel does away with the presence of gases, and the necessity of air, and the temperature can be made chemically neutral or it can be made chemically reactive in any way desired by the introduction of any gas or vapor.

5. The composition and the proportions of the materials put into the furnace can be varied at will; there is no restriction or requirement imposed by fuel, affecting the amount or quality of any material used for the charge; additions for varying the character and composition of the charge can be readily made at any stage, and products of varied kind and quality can be obtained with ease and precision.

Aluminium.—It was this metal which gave France an opening for entering the field of electrometallurgy. It had, it may be said, pre-empted the field of aluminium production at an early date; indeed, it was the first country in the world to produce aluminium commercially. Until 1850 only small quantities of aluminium had been prepared by a very imperfect and expensive process. The market price of this metal was then over 1000 francs per kilogram. At a chemical plant in the south of France, where the Leblanc soda process was in operation, the production of aluminium was begun in 1861 by a chemical process devised some time before (in 1851) by Sainte-Claire-Deville, and which had been developed by him, between 1854 and 1859, to a point that enabled the selling price of aluminium to be reduced to about 300 francs per kilogram, and the production by that process was continued for twenty-eight years (until 1889), when it was replaced by an electric furnace process, which is still in operation, so that this concern enjoys the distinction of being the pioneer in aluminium production. It is now one of the largest producers of aluminium in France. (See Table III.)

The aluminium industry is of special interest and importance both to France and the United States. The two countries share honors for the inventions to which the development of the modern method of aluminium production is due, the names of Héroult and Minet in France and of Hall, the Cowles brothers and Bradley in the United States being those of the pioneers who blazed the path to industrial success, and these two countries are also those having the largest production capacity. Héroult's name deservedly takes precedence over all others in the history of the production of aluminium by electrolysis. His French patent of April 23, 1886, contains the first complete, definite, description of

the process which proved to be (and remained) the most practical and successful one, namely, the process depending upon the electrolysis of alumina dissolved in a bath of fused cryolite; and there is no doubt that he was the first to reduce the invention to practice and to produce aluminium industrially by that process, which is still in general use with modifications and improvements in details which are of relatively minor importance. The following table gives an idea of the relative production capacities of different countries two or three years before the war:



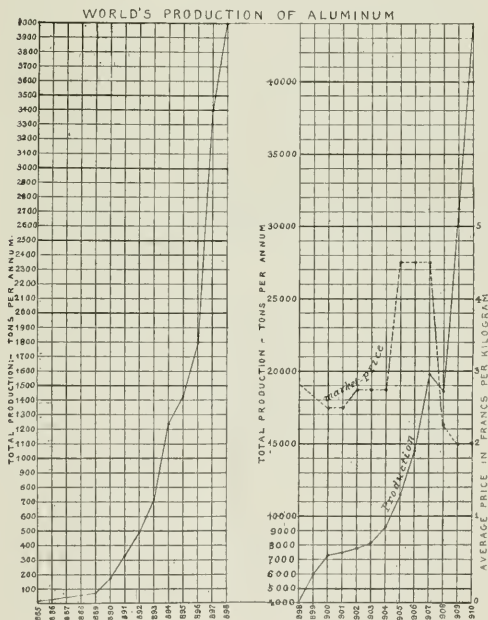
ALUMINIUM PRODUCTION IN DIFFERENT COUNTRIES

The table shows that France led the world, with a production capacity equal to 39.4 per cent of the total. Of the ten French aluminium plants, the nine which are located in the region of the Alps represent an aggregate of 120,000 hp.; the other is located in southern France. It is interesting to note that from 1886 to 1896 it was Switzerland and not France that led the world in production capacity of aluminium. Its production capacity, after that time, remained nearly stationary, while that of France continued to increase.

One important reason why France attained a leading

position in aluminium production was the fact that, at first, and until recent years, practically all the "ore" used for making aluminium (namely, bauxite) came from France. The extensive beds of bauxite found in southern France are still the main source of supply of that material for all the aluminium plants in Europe. The discovery of large quantities of this material in the South in the United States has made this country practically independent of France in this respect. Statistics for 1910 show that out of a total world demand of 271,000 tons of bauxite, France supplied 128,000 tons and the United States 129,000, so that only 14,000 tons came from other countries. The French bauxite is generally considered superior in quality to that from any other source.

In spite of its great advantages in having cheap power, and also the best and cheapest supply of aluminium "ore," France has not retained the leading position which it had for a time, and which it hoped to retain indefinitely, in regard to total yearly production. With a domestic consumption of only about 3000 tons, and a production capacity of 19,000 tons per year, there is a large surplus capacity which must depend on finding a market by exportation. The hopes of France and of all European producers of aluminium to find a market in the United States for a considerable portion of their output were destroyed by our protective tariff.



WORLD'S PRODUCTION OF ALUMINIUM SINCE 1885

PRODUCTION-CAPACITY FOR ALUMINIUM

Country	Number of Concerns	Number of Plants	Aggregate H. P.	Capacity in Tons per Year	Per Cent of Total
France	6	10	140,000	19,000	39.2
United States	3	3	105,000	12,500	25.8
Canada	1	1	20,000	2,500	5.2
Switzerland	1	2	27,000	6,000	12.4
Germany	1	1	5,000	600	1.2
Austria	1	1	5,000	800	1.6
England	2	2	21,000	3,800	7.8
Norway	2	2	21,000	2,100	4.3
Italy	2	2	4,000	1,200	2.5
Total	19	24	348,000	48,500	100.00

The United States has become the country of greatest demand for and greatest production of aluminium. The war has further increased the demand and has stimulated the production to very high degrees. The American producers of aluminium are in control of the market at present, with good prospects of retaining that control.

The lack of sufficient market to keep the French aluminium plants fully occupied has necessitated the diversion of a considerable portion of their capacity to other electrometallurgical or electrochemical work, including making of carborundum, steel, ferro-alloys, etc.

Electrosiderurgy.—Even after the electric furnace had been in successful operation for a period of ten years or more in the production of aluminium on a large commercial scale, its application to the metallurgy of iron and steel was still regarded as of doubtful utility, and as having a rather limited field. There had been an enormous amount of laboratory and experimental work done, both in Europe and in America, in devising and trying out processes and methods of using the electric furnace for making steel, but the outcome of all these efforts had been very disappointing and discouraging. The metallurgist, who had to produce results industrially and commercially, and who was doing it with the methods already in use, could not very well be content with a new process, even though it was "electric," just because it would work; no matter how perfectly it worked, he insisted that it must pay, and, unfortunately, while it was, in most cases, easy enough to satisfy him that the electric furnace would "work," it was usually impossible to demonstrate to his satisfaction that it would "pay."

The aim and the hope, at first, were to make the electric furnace "work," and also to make it "pay," in the larger field of steel making, as a competitor or a substitute for the older methods of making low-priced steels, depending on the use of furnaces heated by coke or other fuel. It became apparent in time that while the electric furnace might be able to compete with the crucible in the productions of steels and ferro-alloys of higher grade and price, its hopes of success in competition with the open-hearth furnace must be indefinitely deferred. These prospects were foreshadowed quite clearly as early as 1904, in a comprehensive study published by the Canadian Government, which was entitled "*Report of the Commission appointed to investigate the different electrothermic processes for the smelting of iron ores and the making of steel, in operation in Europe.*" In the "general conclusions" formulated by the distinguished metallurgist and steel and iron expert attached to this commission, Mr. F. W. Harbord, of the Royal Engineering College, London, it was already possible to see the trend of the applications of the electric furnace and their limitations. It was stated, in these conclusions, that "steel equal in all respects to the best Sheffield crucible steel can be produced by electric furnace processes, at a cost considerably less than the cost of producing a high-class crucible steel"; also, that "structural steel to compete with Siemens or Bessemer steel could not be economically produced by the electric furnace, and that such furnaces could be used economically for the production of only very high class steel for special purposes." It was admitted that pig iron of any desired kind and quality could be readily produced; but it was pointed out that its production on a commercial scale at a price to compete with the blast furnace was possible only when electric energy is very cheap (not over \$10 per horsepower year), and fuel very dear (at least \$7 per ton). The further improvements made in recent years in blast furnace methods of producing pig iron, which led to further reductions in the cost of production by such methods, have increased still more the handicap against the electric furnace. The fact is that in the field of pig-iron production, the electric furnace instead of overtaking the blast furnace, has found itself falling more and more behind it, in point of cost, in recent years. At the present time the electric furnace could not compete with blast furnace in the production of pig iron, unless electric power cost much less than \$10 per horsepower year, and coke much more than \$7 per ton; so that the prospects are even more doubtful than before. It took considerable time, and many experiments, some of which were costly,

to make it quite clear that the electric furnace had better prospects of industrial success in competing with the crucible than with the blast furnace. After this lesson had been learned—in other words, after it was realized that the electric furnace might find a place and field of usefulness somewhere between the crucible and the furnace—the efforts made to adapt the electric furnace to purposes for which it was better suited were made more intelligently, and they began to yield results, and it was not long before the electric furnace found a permanent place and a profitable field in the metallurgy of steel. It has shown itself capable of improving the quality of the product and reducing its cost in many cases, and in the last fifteen years a new branch of the steel industry, "electrosiderurgy," has been developed, which has attained considerable importance.

This new industry has made great progress in France, where the cheap hydroelectric power available in the "white coal" region is very favorable to its development. In 1914 there were twenty-five plants equipped with electric furnaces for making steel, and two such plants under construction, practically all of them in the "white coal" region (see Table IX). The aggregate charge capacity of the furnaces in these plants was over 135 tons, the largest furnaces being of 12 tons charge capacity. Of course, the war has caused an enormous increase in production capacity in all these plants, and in many other electrometallurgical plants in which electric furnaces were formerly used for the production of aluminium, calcium carbide, etc., the furnaces have been replaced or transformed so as to make steel.

The commission had the privilege of visiting one of the largest "electrosiderurgical" plants in France, namely, the works of the *Compagnie des Forges et Aciéries Electriques Paul Girod*, and the works of the *Société Electro-Métallurgique Procédés Paul Girod*, which are affiliated establishments, located together at Ugine, in Savoie (in the "white coal" region).

The first of these establishments is equipped for making electric steel castings up to 25 tons, and also with the necessary machinery for rolling, forging, turning and machining heavy steel pieces, for making ordnance, also war munitions and war material of various kinds. The most interesting and novel feature of this establishment to the commission was the electric steel furnace equipment, which serves for producing steel for making steel billets for the forges, and also for melting steel for making steel castings in the foundry. The furnaces and their operation were fully shown and explained to the commission. The operations incidental to the charging, the beginning and the end of the furnace "heats" and making of castings were seen by the commission. The furnaces used are of the Girod type, the invention of M. Paul Girod.

Girod Furnace.—This furnace is very ingenious in design and seems extremely well adapted to its purpose. It is a hearth furnace of a kind which can be tilted like a Bessemer converter. It suggests a huge covered iron ladle held in a tilting frame. Instead of being charged through the top, like a Bessemer converter, however, it is charged through an opening in one side, which is fitted with a sliding door, through which the slag is also removed. On the opposite side of the furnace is another opening—the taphole—for discharging the molten steel. The steel frame carrying the furnace can be tilted to one side for removing the slag through the charging door or to the other side for tapping the furnace and discharging it. The frame tilts on huge trunnions mounted on large roller bearings. The tilting is done by an electric motor or by a hydraulic plunger. The hearth of the furnace is square, with rounded corners, or it may be circular.

TABLE I—ELECTRIC STEEL PRODUCTION

	Tons		
	1911	1912	1913
France	13,850	15,818	20,757
Germany and Luxembourg	60,654	71,177	88,881
Austria	21,606	19,891	24,902
Hungary	1,261	1,665	1,935
United States	29,571	18,602	.....

The bottom and sides are lined with refractory material. As the steel made is "basic," the lining is of basic character. Two basic lining materials, "magnesite" and "dolomite," have been used. Dolomite has been found preferable, and is now used altogether; it contains about 50 per cent of lime and 35 per cent of magnesia, the remaining 15 per cent being mainly silica and iron. The lining endures about 120 heats in the small furnaces and 90 to 100 heats in the large furnaces. The side walls need more frequent repairs than the hearth, especially at the slag level, where they are most strongly attacked and wear out most rapidly, requiring partial repairs with dolomite between the heats. The bottom is not usually repaired until the side walls are repaired, and, as a rule, only an upper layer or crust of the bottom is removed down to a depth of 4 to 6 in., which is then replaced by a new layer of dolomite, which is tamped into a solid pavement. The roof of the furnace, which is arched, is lined with silica bricks, carefully fitted together into the iron "cover" of the furnace. This lining stands about seventy heats in the small furnace and about fifty heats in the large furnace. The total maintenance cost of the furnace lining is said to be about 30 cents per ton of steel. The electric current used in the furnace is conveyed to the furnace charge by large carbon electrodes suspended in a support frame above the furnace, and passing downward in a vertical line through the cover or roof of the furnace. The supporting frame holds up each carbon at a height such that its lower end is near the slag level, as is usual in electric steel furnaces. The electric circuit through the furnace is completed by the current passing through the charge to reach the furnace shell. There are several steel electrodes (water-cooled) protruding upward through the hearth lining which serve as collectors for the return current. These are located as far away as possible from the path of the carbon electrodes to compel the current to go through as large a mass of the charge as possible on its way from the carbon electrode to the steel electrodes. It is stated that the passage of the current produces electromagnetic rotation in the charge which stirs up the bath and hastens the chemical reactions produced in it. The carbon electrodes are gradually consumed in the furnace and have to be replaced periodically. The water-cooled steel electrodes last indefinitely.

TABLE III—PRODUCTION OF CHEMICALS BY ELECTROTHERMIC PROCESSES

Countries	Tons Produced		
	Cyanamide	Calcium Carbide	Calcium Nitrate
France	7,000	1,000	.....
Austria-Hungary	10,000	2,000	.....
Italy	10,500	.....	.....
Switzerland	10,000	300	.....
Norway	40,000	.....	22,000
United States	24,000	5,000	.....
Germany	25,000	.....	.....

The Girod furnace can be operated by either continuous or alternating electric current, because its operation depends on "electrothermal" action only, and does not utilize electrolytic action at all. The current used at Ugine is alternating current of low frequency (25 cycles). The source of supply is "three-phase." The smaller furnaces (of 2 to 3 tons capacity) are of single-phase type, being supplied with current drawn from one phase only of the electric current supply system. The large furnaces (of 10 to 12 tons capacity) are of three-phase type, and are supplied with current from all three phases of the supply system. The small furnaces have only one carbon electrode (for single-phase current). The large furnaces have four carbon electrodes, and when used with three-phase current, as is the case at Ugine, one of the three phases is connected with two carbon electrodes. The current per phase is about 8000 amp., and the voltage ranges from 60 to 75 volts, according to the charge. Usually the voltage is about 65 volts for the small furnaces and about 70 volts for the large furnaces. The amount of current passing through each electrode is controllable individually. This may be done by hand or it may be done automatically by an ingenious regulating apparatus. The current is usually controlled by hand regulation for a few moments at the time of turning it on the furnace when starting a heat; after that it is regulated by the automatic controller, which can be set for any desired amount of current.

The six furnaces that were in operation have an aggregate charge capacity of 33 tons. Two more furnaces were under construction, one of 2 tons, one of 12 tons, which will make the aggregate charge capacity 47 tons. Each furnace can be used for making at least three heats per day. Each heat requires about 6½ hours. With the six furnaces already in use there was no difficulty in making 3000 tons of electric steel per month, or an average of 100 tons per day.

The operation of this form of electric furnace is much like that of a basic open-hearth furnace. It can be used, like the open-hearth furnace, for making steel either by the Siemens ("pig-and-ore") process or else by the Siemens-Martin ("pig-and-scrap") process. These two processes, it is well known, differ in the manner in which the excess of carbon in the

TABLE II—PRODUCTION OF "FERRO-ALLOYS" IN FRANCE, INCLUDING FERRO-MANGANESE, FERROSILICON, FERROCHROMIUM, FERROTUNGSTEN, ETC.

Years	Tons Produced		Per Cent of Total	Total
	Coke Furnace	Electric Furnace		
1905	32,561	11,706	26	44,267
1906	39,194	13,657	26	52,851
1907	41,489	15,740	27	57,229
1908	46,693	15,329	24	62,022
1909	39,206	14,867	28	54,073
1910	40,106	24,333	36	64,439
1911	38,770	31,270	44	70,040
1912	46,372	30,660	40	77,032
1913	49,287	32,230	40	81,517

TABLE IV—PRODUCTION OF ALUMINUM

Countries	Tons Produced										
	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	
United States and Canada	3400	3900	4,500	6,000	8,000	6,000	16,000	29,500	20,300	26,300	
Germany	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
Austria-Hungary	2500	3000	3,000	3,500	4,000	4,000	5,000	8,000	8,000	12,000	
Switzerland	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
France	1600	1700	3,000	4,000	6,000	6,000	6,000	9,500	10,000	13,000	
England	700	700	1,000	1,000	1,800	2,000	2,800	5,000	5,000	7,500	
Italy	.....	.....	.....	.....	.....	600	800	800	800	800	
Norway	.....	.....	.....	.....	.....	.....	600	900	900	1,500	
	8200	9300	11,500	14,500	19,800	18,600	31,200	43,800	45,000	61,100	

TABLE V—PRODUCTION OF CALCIUM CARBIDE BY THE ELECTRIC FURNACE IN 1913

Countries	No. of Plants	TONS			
		Produced	Consumed	Exported	Imported
France and colonies	16	45,000	45,000	.....	.....
Sweden and Norway	8	75,000	3,000	72,000	.....
Other European countries	42	130,000	164,800	51,000	85,800
Balkan countries	1	1,000	4,000	.....	3,000
United States	3	70,000	55,400	14,600	.....
Canada	3	12,000	6,000	6,000	.....
Latin America	1	.....	28,300	.....	28,300
Africa	.....	.....	6,500	.....	6,500
Australia	.....	.....	20,000	.....	20,000
Japan, China	3	6,000	6,000	.....	.....
Total	77	339,000	339,000	143,600	143,600

pig iron is removed in order to convert the pig iron into steel. The first process accomplishes the desired result by the oxidation of the carbon by the action of oxygen introduced in the furnace in the form of iron ores of the oxide variety, such as red or brown haematite or magnetite iron ores; the second process accomplishes the desired result by dilution of the carbon, by the addition to the furnace charge of sufficient quantities of scrap iron and steel, which contain carbon in much smaller proportion than pig iron or cast iron.

As with the open-hearth furnace, the charge may be melted down in the furnace itself, or it may be delivered into the furnace in the molten state. The latter is the preferable way, because the heat required for melting purposes can be obtained more cheaply in an open-hearth or a cupola furnace than by electrical means. The most practical way to use the electric furnace, in fact, is to restrict its use to processes and operations which cannot be done so well, if at all, or so cheaply, by any other means.

The process of making steel by the electric furnace comprises two phases or stages, the "oxidation" or "dephosphorization" stage and the "deoxidation-and-desulphurization" stage. In the oxidation stage the metallurgical reactions are substantially the same as in the open-hearth furnace; in the second or "deoxidation" stage they are somewhat different, owing, in a great measure, to the fact that the atmosphere in the electric furnace is entirely free from sulphur and almost entirely free from oxygen, whereas both of these reagents always exist in the open-hearth furnace, the former being due to the fuel and the latter to the air passing through the furnace. The absence of sulphur and oxygen in the atmosphere of the electric furnace is of no special advantage in the oxidation stage of steel making; it may perhaps be regarded as a disadvantage; but it is of the greatest advantage in the deoxidation stage of the process. The superior quality of the steel obtained by the electric furnace is, indeed, believed to be due in considerable measure to the neutral, non-oxidizing condition of the atmosphere of the electric furnace.

In the first or oxidation stage the presence of oxygen in the furnace atmosphere may be helpful, because the object sought is to oxidize the impurities, carbon, manganese, sulphur and especially phosphorus, as the first chemical step in their removal from the metal. In this stage an oxidizing slag which is highly basic is formed by the melting of iron oxide ore and lime, which are added to the charge from time to time, with, perhaps, a small quantity of silica. This slag, which floats above the molten metal, furnishes, from the iron oxide, the oxygen necessary for oxidizing the phosphorus to phosphoric acid, and it also furnishes, from the lime, the "base" necessary for combination with the phosphoric acid to form phosphate of lime, which

remains in solution in the slag. The iron oxide also furnishes oxygen for oxidizing the carbon to carbonic oxide (which burns, producing carbonic dioxide, if there is oxygen in the furnace atmosphere), and also for oxidizing a part of the sulphur to sulphur-dioxide, which escapes. Phosphorus, which is the most objectionable impurity, is the easiest to remove completely. The oxidation of the carbon and manganese proceeds more slowly, in spite of the high temperature in the furnace. Practically all the phosphorus is removed during this stage of the refining process. The sulphur is only decreased by from 25 to 33 per cent.

At the end of the first stage the slag is removed and fresh lime is added to remove the last traces of phosphoric acid and prevent rephosphorization of the bath, by the additions of deoxidizing reagents (containing carbon, silicon, etc.), made to it in the second stage.

In the second stage the presence of oxygen in the furnace atmosphere is actually harmful, the object now being to remove, as completely as possible, the oxygen absorbed by the metal during the dephosphorization stage. The first step is to introduce a small quantity of deoxidizing reagents like carbon, ferro-silicon, etc. The molten metal is then covered with a very basic slag produced by the melting of lime, to which is added a small quantity of sand and fluorspar. The proportions used per ton of steel are the following: About 1 kilo (2.2 lb.) of ferrosilicon (containing 50 per cent of silicon), about 20 kilos (44 lb.) of lime, and 3 kilos each (6.6 lb.) of sand and fluorspar. The ferrous oxide formed on the unprotected surface of the metal at the end of the first stage, after the removal of the oxidizing slag, is dissolved by the deoxidizing slag, which turns black. It is necessary to secure the complete deoxidation not only of any iron oxide contained either in the metal or in the slag, but also of the lime in the slag. A certain excess of deoxidizing reagent is therefore desirable. This is provided by the addition of a small quantity of powdered petroleum coke (1 to 2 kilos., or 2 to 4 lb.) per ton of steel. The complete removal of the sulphur, which is so desirable in steel making, depends at this juncture upon the complete deoxidation of the lime in the slag, as this furnishes the reagent (calcium) necessary for the elimination of the sulphur present in the molten metal. We now see the great advantage of the electric furnace. The presence of oxygen in the furnace atmosphere would interfere with the reaction just mentioned, by causing the reoxidation of the calcium into lime. This is precisely what would happen in a Bessemer converter or in an open-hearth furnace; and it is for this reason that in these processes the sulphur cannot be removed by the deoxidation method just mentioned. The advantage of that method is shown by a comparison of the practical results. With the open-hearth process there is much difficulty in bringing the percentage of sulphur down to 0.03 per cent, and still more difficulty in reducing it to 0.02 per cent, whereas with the electric furnace it can readily be brought down to less than 0.01 per cent.

TABLE VI—EXPORTS OF FRENCH FERRO-ALLOYS

Exported to	TONS EXPORTED									
	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912
Germany	.....	18	227	1715	2561	2282	2376	2878	2251	2548
Belgium	263	345	3069	3960	1859	3783	2143	1516	1816	1594
Great Britain	590	434	1150	1248	1914	1715	2321	3566	3189	4036
Switzerland	.....	.....	154	.....	1160	578	1397	1672	1676	.....
United States	66	.....	.....	450	.....	.....	980	256	235	.....
Other countries	63	163	598	681	1335	633	1618	1905	2498	2218
Totals	892	1160	5044	7758	8149	9576	9236	12,242	11,682	12,307

TABLE VII—EXPORTS OF FRENCH ALUMINUM

Exported to	TONS EXPORTED										
	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	
Germany.....	24	148	245	540	506	457	1479	1394	1681	1182	
Belgium.....	33	107	163	122	122	173	156	89	810		
Great Britain.....	107	116	203	326	122	354	146	338	548		
Italy.....	45	75	164	122	23	164	122	23	164	122	
Russia.....	373	336	296	291	14	280	393	165	176	256	
Switzerland.....	33	296	70	12	142	1519	1802	1293	1484		
United States.....	101	101	86	43	16	259	524	292	393	1354	
Other countries.....	125	101	86	43	16	259	524	292	393	1354	
Total.....	662	663	925	1474	1118	1332	4525	4145	4060	6626	

After the desulphurization has been carried to the point desired, the deoxidizing slag is removed, carrying the calcium-sulphide, which, while almost insoluble in the metal, is easily soluble in the slag. The finishing touches are given to the metal by adding whatever is necessary to give the metal the composition and properties desired; and the metal is then emptied out into ladles for use in making ingots or castings.

If desired, the whole series of refining operations above mentioned may be repeated on the molten metal before taking it out. This refining by repetition of the process may be necessary in cases where the phosphorus and sulphur were present in unusually large quantity or where a very high degree of refining is to be attained.

Another advantage of the electric furnace is that the molten steel clears itself of suspended particles of slag more easily and completely than is the case with either the open-hearth or the Bessemer process.

The oxygen of the air, in the open-hearth furnace, causes oxidation of the carbon in the molten mass, forming carbonic oxide gas bubbles; and these, as they escape, cause a boiling effect, which tends to churn the slag and mingle particles of it with the metal mass. On the other hand, in the electric furnace, the molten mass is less agitated and somewhat more fluid, by reason of the slightly higher temperatures produced; there is less tendency for slag particles to become mixed with the metal, and it is less difficult for the suspended particles to rise to the surface.

It is seen from what precedes that there are good reasons, from the metallurgical point of view, for the better quality of the steel produced by the electric furnace. Comparing the electric furnace with the crucible furnace, we find that it has important advantages: First it can treat a larger charge (from 1 to 10 tons or more), the crucible being limited to charges of from 75 to 100 lb.; second, the heat is applied directly to the charge itself, and, therefore, very efficiently, while

TABLE IX—TABLE OF ELECTRIC FURNACES FOR MAKING STEEL IN OPERATION OR UNDER CONSTRUCTION IN FRANCE IN 1914

Type of Furnace	No. of Companies Using Same	Aggregate Capacity, Metric Tons	H.P.	Products
Heroult.....	5	10	....	Tool steel Billets Castings
Heroult.....	2*	55	....	....
Schneider.....	1	2.5	....	Sundry
Girard.....	6	33.5	4600	Tool steel Billets Castings
Keller.....	7	19	2280	Fine steel Billets Castings
Chaplet.....	3	13	2200	Fine steels
Rochling-Rodenhauser.....	1	3	350	Fine steels Billets
Kjellin.....	1	1.5	400	Fine steels Billets

*Under construction. All the others were in operation.

in the case of the crucibles it is applied to the outside of a vessel made of refractory material, of low heat conductivity, and, therefore, in a much less efficient manner; third, while sulphur and phosphorus can be removed in the electric furnace, this cannot be done in the crucible. These advantages point to the probability that the electric furnace will, in time, demonstrate its ability to do all that can be done by the crucible furnace, not only as well but better, and, besides, much more cheaply. It has already pre-empted a field between the crucible and the open-hearth furnace, in which it is preferable to both of these for certain purposes.

A very interesting application of the Girod electric furnace which was observed at Ugine is its use in foundry work. At the time of our visit there several of the furnaces were in use for melting steel for making high-grade steel castings. The furnace charge consisted of steel turnings, shavings, trimmings, etc., with some scrap steel and also ingots, all used in certain proportions. The large proportion of small turnings and shavings in the charge was noted. The electric furnace has proved exceptionally useful for remelting this kind of scrap. Evidence of this was seen at several other places, where the same thing was also done. It is doubtful if the recovery of scrap steel can be obtained with as much success and at as low cost by any other method. The charge, after being melted, was subjected to a purifying and refining process, same as when steel is to be made from pig iron. The oxidation and de-oxidation stages were gone through, the metal was sampled from time to time during the heat, the necessary additions of lime and other reagents were made at the proper time, the operation being continued until the sampling tests showed that steel of the desired kind and quality had been obtained, after which the molten steel was emptied from the furnace into ladles and conveyed to the foundry.

M. Girod has himself set forth the advantages of the electric furnace in steel foundry practice in a paper published by him on that subject in *Metallurgical and Chemical Engineering* for October, 1912 (Vol. X, pp. 663-665). The following quotation gives a summary of the merits claimed for this method: "The electric steel furnace is especially well suited for castings, since it offers the possibility of holding finished steel in the furnace as in a mixer and to tap it at intervals as desired into small ladles. Different taps can be made at different temperatures, lower temperatures being used for larger molds and higher ones for small castings. The steel can be heated to any desired temperature and castings can be made very thin-walled and of

TABLE VIII—EXPORTS OF FRENCH ELECTROCHEMICAL PRODUCTS (METRIC TONS)

Exported to	Chloride of Potassium	CHLORIDE OF				NITRATE OF	
		Aluminum	Lime	Magnesium	Potassium	Lime and Cyanamide	Sodium
Colonies.....	171	179	4	169	477	193	1,641
Germany.....	67	408	...	34	...	235	3,412
Belgium.....	94	3,896	...	...	...	77	1,050
Spain.....	17	3,845	...	50	...	176	3,518
Great Britain.....	244	2,637	8	...	...	116	478
Italy.....	132	390	...	...	312	16	...
Switzerland.....	...	105	31	...	...	...	...
United States.....	...	1,251	...	...	...	...	...
So. America.....	47	884	...	16	...	58	...
Japan.....	730	...	...	...	...	...	...
Other countries.....	245	...	303	17	2	197	18
Total.....	1747	...	13,857	60	271	789	10,233

a very small size. Pieces from $\frac{1}{2}$ lb. and upward with sections of 7 to 7 mm. thickness can be cast without any difficulty. With the electric furnace one is sure to have for castings an absolutely dense steel without blowholes and pipes."

The steel castings seen in the foundry at Ugine were of the very finest quality and they indicated that the claims made for the method used were not unfounded. The results obtained at Ugine have led one of the largest steel companies in the United States to install a Girod furnace at one of its works. This may be regarded as further indication that this furnace is considered capable of industrial application.

Ferro-Alloys.—There is, perhaps, no application of the electric furnace in which it has been more successful than in the manufacture of certain alloys known as "ferro-alloys." France has played a leading part in the erection of this new branch of electrometallurgy. These alloys, composed of iron or steel combined with one or more metals, are of great importance in metallurgy. They have indeed been the means by which wonderful progress has been made in the manufacture of steel of higher grades and of special kinds suited for specific purposes. The ferro-alloys may be used in two ways, according to their properties, and the manner of their use. Some may be regarded as being in reality reagents; they are specially suited to serve as deoxidizers during the process of refining the steel; and, after serving this purpose, they pass out with the slag, leaving no trace in the steel. The others are true alloys; they are specially suited to enter into the steel as a permanent part of its alloy, which produces important changes in its hardness, and other physical properties. The same ferro-alloy may serve in one case the ephemeral purpose of a deoxidizer and in another case the permanent purpose of an alloy.

The ferro-alloys which are specially useful as deoxidizers generally include silicon as one of their constitu-

ents. The list includes: ferrosilicon, ferrosilico-aluminium, silico-manganese-aluminium, silicocalcium-aluminium, and silicomanganese. Of these, ferrosilicon is the best known and most used. The estimated total consumption of ferrosilicon in the world for 1910 was about 60,000 tons. At first this ferro-alloy consisted of "silicious" pig-iron made in the blast furnace from highly silicious iron. It was a weak deoxidizer because it contained only a small amount of silicon (10 per cent to 12 per cent, rarely as much as 15 per cent), with proportionately too much carbon, and also a considerable proportion of sulphur and phosphorus. The electric furnace has permitted the manufacture of a much richer and purer product. It is now made in various grades, suited for different purposes, with silicon contents ranging from 25 to 95 per cent. The grades containing from 25 to 30 per cent and from 45 to 50 per cent are those generally used for deoxidation purposes in steel refining. The 75 per cent and 90 per cent ferrosilicons are also used as deoxidizing reagents, and as alloy for making silicon steels for electric purposes.

Ferrosilicon of high grade (75 to 90 per cent) has also proved useful in foundry work. It is stated that by its use in varying proportions the characteristics of cast iron from the same heat can be so varied as to produce both gray and white castings.

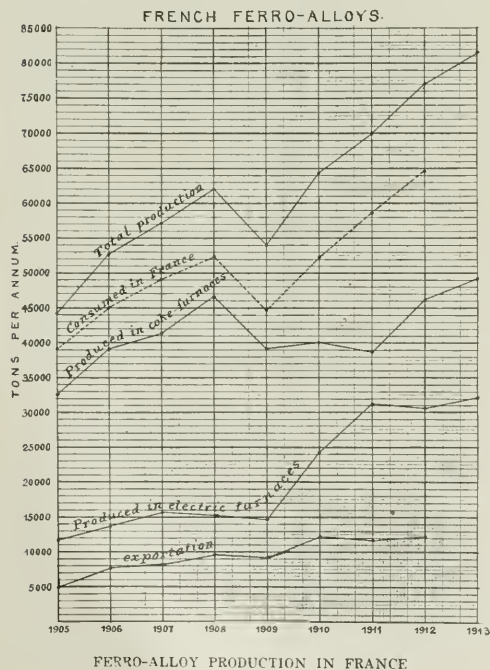
The other deoxidizing alloys serve for various special purposes.

The ferro-alloys of the second group include the alloys which are added to steels of various kinds and qualities in order to produce steels of great hardness, toughness, strength, etc., for making armor, or to produce "rapid" steels and special grades of tool steel. The principal ferro-alloys of this group are: ferrotungsten, ferromolybdenum, ferrovandium, ferromanganese, ferrotantalum. These are all used in considerable quantity. Other metallic alloys used in smaller quantities include: ferrobore, nickel-bore, ferro-uranium, chromium-silicon, aluminium-silicon, manganese-silicon, aluminium-manganese-silicon.

There were in France before the war no less than 13 concerns engaged in this new electrometallurgical industry. One of these is the works of the Société Electrometallurgique Procédés Paul Girod, at Ugine, Savoie, adjoining the steel works already mentioned. This plant is one of the largest producers of ferro-alloys and rare metals in the world. It is a large producer of tool steels and of so-called "rapid steels." The total production of ferro-alloys in France in 1910 was 64,000 tons, of which a little less than half was made in electric furnaces. Since then the production by the electric furnace has been enormously increased.

Pure Metals. Besides producing ferro-alloys of the rarer metals, chromium, tungsten, molybdenum, manganese, etc., these metals are also produced as pure or nearly pure metals by electric furnace methods at many of the French electrometallurgical works. Thus refined chromium and manganese are produced, which contain less than $\frac{1}{2}$ per cent of carbon. Chromium is also produced, containing higher proportions of carbon (from 4 per cent to 10 per cent). Commercial manganese, containing as high as 96 per cent of manganese, with 1 per cent to 2 per cent of iron and less than 2 per cent of carbon, is also produced by the electric furnace. Various alloys of two, three and four of the rarer metals are also produced, including the following: nickel-chromium, nickel-vanadium, copper-vanadium, nickel-molybdenum, nickel-tungsten, ferro-nickel-chromium, ferro-chromium-molybdenum, ferro-nickel-chromium-tungsten; in short, alloys of any kind and of any proportions desired for any specific purposes can be produced.

Zinc. There are deposits of zinc ores in the Pyrenees



which have drawn attention to electrometallurgical methods of producing zinc, both by "electrolytic" and by "electrothermal" processes. A plant in operation at Arudy in the Lower Pyrenees is producing zinc-white containing 99 per cent of zinc oxide by the electric furnace. Another plant has recently been equipped, in the white-coal region, not far from Grenoble, to produce zinc-white from the same ore (zinc blende), by a process, also electrothermal, said to be more economical and efficient.

Other Metals. Considerable attention has been given, in France, to the search for practical methods, either electrothermal or electrolytic, for either producing or refining various metals of more or less usefulness in the arts, such as lead, tin, bismuth, antimony and magnesium. There is no evidence that industrial success has been attained thus far by any of them. There is, however, in operation, at present, in Grenoble, a plant for the production of pure iron by an electrolytic process which is attracting great attention by the remarkable properties and qualities of the iron produced. The process is specially adapted for producing iron sheets and tubes of any size. The samples seen leave no doubt as to the quality of the material. The cost of production is the chief point still in doubt.

Statistics. A few data of statistics are given in Tables I to IX, and some are also shown in diagrams (Figs. 1, 2, 3). Practically no statistics are available in the industries of electrochemistry and electrometallurgy for years later than 1912 and 1913. If such statistics were obtainable, however, they would be entirely unreliable and quite misleading. The fact is that both of these industries have been upset by the war to an extent which, in some cases, amounts to complete upheaval and transformation. This has been due to the necessity of diverting activity from the manufacture of products of less importance to those of greater, in fact of the greatest, importance for war requirements and purposes. It is fully realized, and was frankly stated several times to the commission, that war conditions are not considered a criterion of the outlook and prospects of any branch of these industries after the war. It is expected, in fact, that, even after the war, a certain time must elapse, to allow for a proper period of readjustment and rearrangement, in accordance with the conditions that will be then encountered, before statistics can be obtained that will be sufficiently free from the unbalancing and transitory effects of the war to give reliable indications as to the trend and possibilities of the development in these industries. Under the circumstances, therefore, the statistics available for the years preceding the war are the only ones that can be used as criteria, and these must be used with due reservation, in fact, with much care, as a basis for deductions and conclusions as to the future. Any one who has taken a close look at these industries in France is probably disposed to look for and expect some very interesting developments in them both, after the war.

The author desires to make special acknowledgment to the following persons: to M. Robert Pinot, General Secretary of the French Water Power Association, for the very full and valuable information, statistics, etc., placed at our disposal by him, so courteously and generously, in regard to the development and the status of the various electrochemical and electrometallurgical industries in France; to the manager and assistant manager of the Girod Works, at Ugine, Savoie, for the great pains taken by them to show the Girod electric furnace in every phase of its operation and to demonstrate its practical use for both making steel and steel castings.

Special thanks are due to M. Maurice Damour, Deputy—who was officially charged by the French Govern-

ment with the organization and direction of the trip made through France by the American Industrial Commission—for his untiring zeal and efforts in assisting the members of the Commission, at all times, to obtain technical and industrial information, as well as in making the trip interesting, profitable and agreeable to the Commission; also to the distinguished delegation from the "White Coal Region" who assisted M. Damour in conducting the Commission through the various hydro-electric, electrochemical, and electrometallurgical plants visited by the Commission.

TABLES

The production of steel ingots by the electric furnace in the countries which give that product separately in their statistics is given in Table I. Table II gives the production of ferro-alloys in France, Table III the production of aluminium in different countries from 1903 to 1912, Table IV the production of cyanamide, calcium carbide, and calcium nitrate, Table V the production of calcium carbide in 1913, Table VI the exports of French ferro-alloys from 1903 to 1912, Table VII the exports of French aluminium, Table VIII the exports of French electrochemical products to different countries, and Table IX electric steel furnaces in France in 1914.

Niagara Falls Section of American Electrochemical Society.—The officers for the present year elected at the annual meeting of the Niagara Falls Section of the American Electrochemical Society are as follows: F. J. Tone, president; H. W. Kellogg, vice-president, and A. T. Hinckley, secretary-treasurer.

Lectures at College of the City of New York.—The following lectures, open to the public, are still to be given on the program of the Spring Lecture of the Chemistry Department of C. C., N. Y. (Dr. Charles Baskerville, director). Two lectures have already been given. They are given at 3 p. m. in the Doremus Lecture Theatre, 140th Street and Convent Avenue.

March 23, "The Conservation of Pine Forests Through the Methods of Chemical Research," by Dr. Charles H. Herty, past president, American Chemical Society.

March 30, "The Getting of Wisdom," by Dr. H. K. Mees, director Research Dept., Eastman Kodak Co.

April 13, "Colloids in Pharmacy," by Dr. John U. Lloyd, Cincinnati, Ohio.

April 27, "Some Chemistry of the Tropics," by Dr. L. H. Friedburg, professor-emeritus, C. C., N. Y.

Meeting of Columbia Section of Mining Engineers.—The Columbia Section of the American Institute of Mining Engineers held a meeting at Spokane, Wash., on Feb. 23, as a part of the program of the 1917 Northwest Mining Convention. The following papers were presented:

"Advance in Methods of Ore Treatment During Last Five Years," by Prof. F. A. Thomson, head Department of Mining Engineering, State College of Washington.

"Experiments in the recovery of Tungsten and Gold, Murray District, Idaho," by Dr. R. R. Goodrich, professor of Metallurgy, University of Idaho.

"Progress Report on the Bunker Hill and Sullivan Smelter, Kellogg, Idaho," by a member of the staff.

Annual Exhibit at Ohio Northern University.—The College of Engineering of Ohio Northern University, Ada, Ohio, held its fifteenth annual exhibit and banquet during the week of Feb. 19-23. Lectures on technical subjects were given and the exhibit included drawings, models and machines, representing the work of the students throughout the year.

The Cottrell Process in Practice*

By Linn Bradley

It seems fitting that this Symposium on the Smelter Smoke and Fume Problem is being held at a joint meeting of the New York sections of the American Institute of Mining Engineers and the American Electrochemical Society. The Cottrell process is highly interesting to those who have to deal with problems in electrophysics or those involving the use of electricity at high potentials. The chemist and the chemical engineer are interested not only because of the value of eliminating nuisances and recovering materials now going to waste, but also because of the chemical problems attending the treatment of dust and fume-laden gases by electrical means. The metallurgist's interest is, of course, quite well known. For the members of the Institute, who are interested primarily in mining, the application of the processes should also have an interesting aspect, in that a new method of obtaining valuable ores has been developed which has resulted in the conservation of large amounts of valuable material. The recovery of metals such as copper, silver, gold, zinc, lead and even platinum and bismuth, from the gases coming from smelting and refining operations may be looked upon as constituting a mining field which is in an embryonic state of development.

The smelter fume problem, from both legal and economic points of view, has been discussed in a thorough and able manner by the first speaker, Mr. Ligon Johnson.¹ The next question which arises is that of available methods for solving the technical problems involved in fume prevention or elimination, and it is under this latter heading that the Cottrell process is up for discussion.

In general the problems of fume prevention or elimination may be considered from two standpoints. First, that of the nuisance to the neighborhood; second, that of the values which are recoverable. This latter aspect involves also other economies in plant operation.

It has already been pointed out that sulphur-dioxide and sulphur-trioxide are of prime importance in any discussion of this subject. The large quantity of sulphur-dioxide to be cared for presents one of the most

difficult problems. In considering sulphur trioxide, there should be kept in mind one of the facts with which we are confronted in applying the electrical processes. Generally, when sulphur trioxide is spoken of in a discussion of the fume problem, the compound referred to is not in reality sulphur trioxide, but sulphuric acid, H_2SO_4 . At ordinary temperatures the gases do not contain the anhydride if moisture is present in sufficient quantity to combine with the trioxide to produce H_2SO_4 . The white fume which is referred to as sulphur trioxide really consists of very small particles of sulphuric acid, the strength of the acid depending upon the amount of moisture present, the temperature of the gases and the length of time which has elapsed since the moisture and the sulphur compound have been in contact. This white fume or mist of sulphuric acid is readily collected by the electrical precipitation process. On the other hand, sulphur dioxide, being in the gaseous condition, is not collected, unless provisions are made for its absorption by some reagent previous to treatment in the precipitator and then precipitating the resulting compound.

Very extended and valuable investigations have been made by the smelting companies and by government bureaus looking toward the solution of the sulphur gas problem, and a large amount of useful and valuable data has been obtained. The sulphur must be disposed of in some manner. Converting the sulphur dioxide into elementary sulphur has been tried, and the purification of the gases and compression of the sulphur dioxide into a liquid has been suggested. Cheap methods of manufacturing sulphuric acid for use in the hydro-metallurgical treatment of low-grade ores offers great promise, and efforts which were begun by us a few years ago are now being pushed and it is hoped that results of considerable economic value will soon be made available to plant operators.

The application of the electrical precipitation processes to the recovery of dust and fume in smelters and refineries has already shown that the large losses of the past can now be prevented. The tendency at present is to avoid the construction in new plants, or the use in old plants, of large and expensive dust chambers, as these are now unnecessary. By concentrating all of the fume-collecting facilities at one point enough money has been saved in some cases entirely to pay for the expense of the new and more efficient installation. Furthermore, the transportation problem becomes simplified and it becomes possible to install apparatus for handling the fume in such manner that the health and happiness of the employees are promoted. This is of especial importance when considering fumes and dust carrying large quantities of lead or arsenic.

The treatment of the collected fumes, either chemically or metallurgically, so as to recover the contained values, will not be discussed in this paper because it should be considered as a separate subject.

In the western part of the United States are located most of the large smelters, the principal ones being devoted to the treatment of copper, lead, silver and zinc ores. At these smelters much attention has been given to flotation for some time past. The roasting of flotation concentrates may give high dust and fume losses, but the collection of this material is a comparatively simple matter, as far as the technique of the electrical precipitation processes is concerned. The gases submit readily to treatment, and the values in the collected material are sufficiently high to warrant the expense of a Cottrell precipitator installation and operation.

There are several smelters and refineries in the eastern part of the United States, some of which are located in or immediately adjacent to residence neigh-



FIG. 1—COTTRELL PRECIPITATOR OF STASO MILLING CO., POULTNEY, VT.

For precipitating fine slate dust from the air from crusher building. The left picture shows the clouds of dust. The right picture was taken a few seconds after the current was turned on. 30,000 cu. ft. of air are handled per minute in this installation.

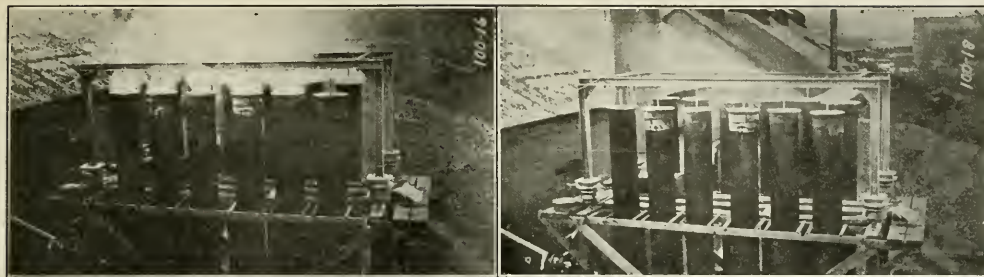


FIG. 2—COTTRELL PRECIPITATOR FOR PRECIPITATING FUMES OF ZINC OXIDE FROM THE GASES COMING FROM THE FIRES IN A BRASS CASTING SHOP, HANDLING 6500 CU. FT. PER MINUTE AT 600 DEG. FAHR.
LEFT PICTURE—CURRENT OFF. RIGHT—CURRENT ON

borhoods. In these cases the nuisance problems, even when the plant is small, often become very acute and considerable effort is required in order to effect a solution.

There are many chemical plants, foundries and factories in the eastern section of the country at which the nuisance problem, as well as the problem of recovering values and improving sanitary conditions, are matters of great importance. The elimination of acid fumes, such as sulphuric, nitric, hydrochloric and even phosphoric, presents a great variety of interesting problems.

In factories it is often desirable to remove practically all the suspended dust particles from the air admitted to the rooms. In the operation of a sand blast equipment a large amount of fine dust is produced and this is best collected at a point near its source. In these foundry and factory problems, where the air is re-utilized after treatment for the removal of suspended dust, the possible saving, due to the conservation of heat in the winter time, is of considerable importance.

The wide range of conditions which confront the engineer in connection with problems of this kind, readily shows the desirability of having a process capable of being applied to a great variety of conditions. The Cottrell process meets this requirement in a very admirable manner, as it can be operated throughout a wide range of temperature up to that at which insulating materials and metals lose their essential qualities, the one as to electrical features and the other as to mechanical strength. Corrosive substances can be readily handled since it is possible to construct the precipitator of material which will withstand corrosion.

Precipitation installations may be divided into two classes; first, those in which the solution of the problem is of such importance as to warrant high installation cost and in which it would be unwise to economize to too great an extent; and second, those in which the utmost economy is required, and in which it is highly desirable to make the operation of the precipitator as automatic and fool-proof as possible, so that the minimum of labor is employed. In some cases the installation is for temporary use only, and in such instances the plant should be designed with this in mind.

In order that a problem may be given thorough consideration, accurate and adequate data must be obtained. Some of the things to be determined are the minimum, average and maximum volumes of gas to be treated; the temperature and composition of the gases; the barometric pressure at the place where the installation is to be made; the origin of the gases; the size, type and arrangement of furnaces, flues, stacks, etc.; the nature and quantity of the fume or dust, and the type of electric power available at the plant. In some instances other information also is required. If such

data are not already available an investigation at the plant is often necessary before the precipitation installation can be designed and constructed, as the precipitators generally are designed to fit special conditions in most of the important problems.

The Cottrell process seems to be very simple, and this idea of simplicity seems to be enhanced when one first sees the operation of a demonstration plant consisting of one small sheet iron pipe, say 6 in. in diameter by 8 ft. in length, with a No. 18 iron wire placed along the vertical axis of the pipe and kept insulated therefrom. The process works so simply and easily that it is very difficult to realize the ramifications of the work in practice. However, in spite of the fact that there are numerous features requiring careful study and analysis, it is well to keep in mind the thought of the simple pipe and wire and to avoid going off on too many tangents and ascribing difficulties, which may arise in connection with the work, to mysterious and complicated causes. As in the case of all new processes, a great amount of time and money has been spent upon the Cottrell process during its progress to the present stage in its evolution, and it has probably reached now the point where generalizations can be safely made. Furthermore, frankness in discussing difficulties and errors should be encouraged. It is true that many mistakes, both of commission and omission, have been made in the past, and that a vast amount remains to be learned and proved in practice in connection with the Cottrell processes. It is to be hoped that at this meeting the engineers and chemists present will volunteer to discuss the problems and troubles which they have encountered in their own plants, to the end that the general knowledge be promoted by the exchange of ideas based upon varied experiences.

The Cottrell process may be considered from two standpoints, for the purpose of this discussion, these being first, the electrical, and second, the mechanical. The electrical has to do with the circuit and the means for generating and controlling the high-tension unidirectional current for use in the precipitator. It is usually necessary to adapt the electrical equipment to the character of power available at the plant, and this dictates in a measure what electrical equipment will be installed. The mechanical features of the precipitation installation will be discussed a little later on.

Electrical Features of Cottrell Process

The alternating current may be obtained either from a motor-generator set, selected for the purpose, or from the plant circuit if the latter has suitable characteristics. In either case the alternating current is fed to a step-up transformer and the voltage raised generally to a point between 50,000 and 100,000 volts, depending

upon the local conditions. The high-voltage alternating current is rectified to an intermittent high-voltage direct current by means of a suitable rectifier. In case alternating current possessing suitable characteristics is available at the plant, the rectifier is driven by a small synchronous motor directly from the plant power circuit, but if a motor-generator set is required the rectifier is connected directly to the shaft of the motor-generator set and driven by it. The rectifier thus operates in synchronism with the current supplied to the transformer. In all cases a simple switchboard is provided for controlling the electric circuit.

Considerable improvement has been made in transformer construction with the aim of obtaining the most reliable apparatus for use with a circuit of this kind in which the electrical strains are much more severe and continuous than in almost any other service. The transformers are often rated at 10 kilovolt-amperes. 50,000 to 100,000 volts, high-tension, with the low-tension voltage at 200 or 400 volts. Usually a number of taps are brought out on the low-tension side so that the high voltage may be varied in steps between 50,000 and 100,000 in steps of about 5000 to 10,000 volts each. The provision of these taps is desirable even with a motor-generator set, but they are more essential when a synchronous motor is used. Some resistance is placed in the low-tension circuit to the transformer for two purposes, one being to obtain a closer control and regulation of the voltage than is possible with the taps alone, and the other being for the purpose of limiting the amount of current which can flow when a spark-over occurs in the precipitator. The electrical equipment, including the transformer, motor-generator set or synchronous motor, and the rectifier, should be protected against electrical surges. Inductances placed in the lines at proper points when used in conjunction with suitable resistances and ground connections, have very beneficial effects, the resistance in the high-tension circuit, used in conjunction with choke coils, is installed for the purpose of dissipating the energy due to surges, thus promoting steadiness and reliability of operation, and permitting higher voltages to be maintained.

Efforts to obtain light on some of the phenomena connected with electrical precipitation have been made in the past by means of an oscillograph, and in some cases valuable information has been obtained. It is necessary to be very careful in the use of an oscillograph, as the results are influenced sometimes in ways not expected. It seems that there are limitations to the use of the oscillograph for telling us the true story of what takes place in this type of electric circuit, the instruments at present available not being useful at the very high frequencies which sometimes occur in the circuit. However, even if the oscillograph curves were thoroughly dependable, their correct interpretation is not always simple.

The electrical equipment, of course, varies considerably in price, but some idea of its cost can be gained from the following: A 10-kilovolt-ampere, 100,000-volt equipment, consisting of transformer, synchronous motor, rectifier and switchboard, may be obtained for about \$1,200 to \$1,500. If a motor-generator set is required the cost will be considerably higher. The larger the power rating of the transformers and motor-generator units, the lower is the cost per kilowatt of capacity. This is especially true with the transformer, as a great deal of the expense is due to the insulation against the high voltage. The difficulty of continuously rectifying excessive currents makes it advisable to keep the power capacity of the electrical sets down to a reasonable value, say between 5 kilowatts and 50 kilowatts; although it must not be inferred that 50 kilo-

watts is the safe upper limit. In connection with an installation of serious importance, relatively speaking, it pays to purchase the very best equipment and to have patience until the same can be obtained, as it takes considerable time to obtain shipment on this class of material. As the work increases in volume, it becomes more and more possible to carry such electrical equipment in stock, and it seems that enough commercial installations have already been made to warrant this action.

A few words upon the question of synchronous motor versus motor-generator operation may be called for at this point. It has already been shown that the first cost of the motor-generator set is greater than that of a synchronous motor, and that one acts as a substitute for the other. With a motor-generator set the operator can obtain a very close control of the voltage, while with a synchronous motor the variation in voltage on the transformer is dependent upon the variation in voltage of the plant circuit, and if this varies rapidly or throughout too great a range, at the point where the transformer leads are connected to the local power line, the voltage in the precipitator will tend to fluctuate accordingly. This fluctuation may be prohibitive for successful operation, and it is thus obvious that the characteristics of the plant circuit, at the point where the power for the electrical precipitation installation is to be taken, should be thoroughly investigated and the future changes considered before the type of electrical equipment is decided upon.

Sometimes 25-cycle power is preferable to 60-cycle. This is the case when it is desirable to operate mechanical rectifiers in locations where it is difficult to maintain the insulation, as in acid plants, and it is therefore desirable to build the moving parts of the rectifier entirely of inorganic insulating material. In other cases, where it is desired to rectify very high voltage, the low speed of 750 r.p.m., usual with 25-cycle operation, as compared to the speed of 1800 r.p.m., with 60-cycle operation, permits the use of a rotating rectifier of greater diameter.

Investigations are being conducted with the object in view of improving the electric circuit and to further increasing the reliability and usefulness of the Cottrell process.

The operating conditions of the precipitators themselves affect the electric circuit. Some of the conditions which may be mentioned in this connection are leaky insulators, changes in gas composition and temperature, poorly built or poorly spaced electrodes, deposits on the electrodes, etc. All of these features should be carefully considered in designing the installation.

Mechanical Features of Cottrell Installation

The precipitator proper may now be considered from the mechanical point of view with special reference to the condition of the gases, the character of the dust and fume, and type of electrodes, the insulators, the effect on draft and on the operation of the furnaces, etc.

We have found that serious and baffling technical difficulties have been encountered in operation of large-scale precipitation installations, even when successful small-scale tests with the processes had been made before building the precipitator. After solving some of these difficulties and determining their cause we have concluded that even after it has been found possible to operate the Cottrell process satisfactorily on a given gas and fume with a single-pipe test precipitator, we should proceed to make tests under the entire range of operating conditions then existing or to exist in the plant. After concluding such tests the large precipitator for commercial operation in the plant should be so

designed, constructed and operated that no extraneous factors are introduced. In other words, efforts should be concentrated on making it certain that the conditions in each pipe of the large precipitator will correspond exactly with those in every other pipe, and at the same time be identical with the conditions encountered in conducting the tests with the single pipe. The slogan "Make every pipe a single pipe" has proven valuable, and has aided in keeping efforts properly directed.

Some of the factors which affect precipitator operation are as follows: Character of the dust and fume content of the gases; gas composition and temperature; gas speed and density; number and size of fume particles per cubic foot of gas and per unit of time per unit of electrode surface; the shape, size, length and composition of the electrodes; and the amount and character of deposit on the electrodes. Since all of these things have an effect on operation, if single-pipe tests have proved that satisfactory results may be obtained throughout the range of working conditions, the plant operator would do well to confine his efforts to insuring that all the gas and electrical conditions in each pipe correspond to those which were existent in the single-pipe tests. Unless these conditions are actually duplicated and not merely assumed to be so, one can well go astray and be a long time in obtaining the results which he seeks.

To illustrate how important this point of view is, suppose we have a precipitator containing several pipes each with its axially placed discharge electrode, and suppose that this precipitator has no upper gas chamber or header box, i.e., it is open at the top so that the gas passes from the upper end of each pipe directly into the atmosphere. One can readily understand that under certain conditions air can enter one or more of these pipes and pass downward through the pipe and then mix with the hotter gases in the lower gas chamber or

header box, and thus produce a difference in the gas conditions in the pipes. That is to say, the gas in one or more pipes is different in temperature, velocity, fume density and composition, from the gases in other pipes. Unless the gases in all the pipes have the same characteristics in all respects it will be necessary to keep the voltage low enough to prevent sparkover in the gas which is, electrically speaking, the weakest.

Suppose that there is an excessive temperature in even one or a few pipes of the precipitator, and that this condition continues for only a fraction of a minute at a time, but is occasionally repeated, it will be seen that the voltage which can be maintained in the precipitator as a whole will be limited to that which the weakest gas will permit, and this in turn affects the entire operation of the precipitator. From a study of the above facts it is plain that in order to obtain the maximum results from any precipitator the gases must be uniformly mixed and uniformly distributed through the various pipes and the precipitator built and operated in such manner that each pipe has exactly the same duties to perform, under identical conditions.

In an installation at a smelter in the west there was presented a very difficult problem and the technical results were very unfortunate because the truth of the facts just mentioned was not fully recognized. It is very difficult to investigate phenomena of this character in a large commercial precipitator, and one might say with reason that all such difficulties should be run to earth in the laboratory before an attempt is made to solve them in a commercial plant. Unfortunately, however, such problems as these have almost never presented themselves in laboratory investigations in the same manner as they have in the field, and we are confronted with the time-worn statement that "necessity is the mother of invention," so ingenuity is drawn upon in an effort to solve the problems. These difficulties have been carefully studied in connection with several commercial installations, and success has been finally obtained by proper application of the methods described above.

It has often been stated that the treatment of zinc fume by the Cottrell process presents problems peculiar to this metal, but our results in practice seem to deny the truth of such a statement. The phenomena which have been encountered in connection with the precipitation of the zinky fume from brass foundries have given us some very useful and valuable information, and owing to the fact that we have encountered similar phenomena in the treatment of fumes containing volatilized lime, potash, and even sulphuric acid mist, the conclusion seems warranted that zinc itself and its compounds do not possess any unusual and exclusive properties as far as electrical precipitation is concerned. Fig. 3 shows a precipitator in successful operation for collecting brass foundry fume containing as high as 60 per cent zinc, mostly in the form of oxide.

It having been considered necessary to look for reasons for the difficulty encountered in treating certain non-conductive gases, a survey was made of all the problems with which we have had any experience. One of our first clues came from some work we had conducted in connection with the precipitation of anhydrous tin chloride. We found that if we introduced the proper amount of steam and thoroughly mixed it with the gases prior to treatment electrically, precipitation was made very easy, while without the addition of this moisture good precipitation was impossible. The phenomenon was very striking. By a very slight turn of the steam valve so as to introduce just sufficient moisture, the operation of the precipitator was immediately changed and instead of a condition of violent



FIG. 3—COTTRELL PROCESS INSTALLATION FOR PRECIPITATING ZINC OXIDE FUMES FROM A BRASS CASTING SHOP
Precipitator units installed on roof of brass casting shop.

sparkling steady operation with a good flow of current, such as is always desirable, was obtained. It occurred to us that the dehydrating action of the tin chloride had a very important effect upon the operation of the precipitator.

The same phenomena appeared when we started work on the precipitation of zinc oxide fumes, and after considerable investigation it was found that with the introduction of a proper amount of moisture in the proper manner, these fumes could be handled very successfully at temperatures even as high as 600 deg. to 700 deg. Fahr.

The mere introduction of moisture into the gases, however, does not suffice, as was found out to our bitter disappointment when we first made a test upon these gases after introducing moisture. It is necessary, according to our experience, if best results are to be obtained, to introduce the moisture in such manner that it becomes thoroughly mixed with the entire body of gases prior to subjection to treatment, and the installation should be so arranged that this uniformity of gas composition, fume burden and temperature is maintained for reasonable periods.

Cold and dry air, such as exists in the winter time, should not be allowed to enter any part of the precipitator, if the evidence from tests indicates that the resulting gas condition will necessitate a lowering of the voltage on the precipitator. This shows that even the geographical location of the precipitation installation, as well as the altitude, are important factors, as some have warm and moist atmosphere, while others have the opposite. In some cases the precipitator pipes should be enclosed to protect them from winds. If the precipitator has not an upper header, provision should be made to prevent wind sweeping down upon the open-ended pipes and creating uneven pressure zones above them, as this affects gas distribution, etc.

One of the most suitable methods for insuring uniformity of distribution in vertically positioned precipitator pipes is to place a specially designed orifice at the top of each precipitator pipe, thus creating a slight pressure difference, amounting to perhaps 0.05 to 0.10 in. of water, across these orifices when gases flow through them. The gases should be introduced into the bottom header and taken away from the upper header, if an upward pass is used, and vice versa if the gases pass downward through the pipes, in such manner that only slight pressure differences (static or kinetic) are created throughout the mass of the gases in the headers. These precautions will insure the gases flowing uniformly in each of the pipes, and will furthermore insure a uniformity of composition, temperature and fume burden if the gases have been thoroughly mixed, and this in turn makes it certain that the duty of each pipe is equal to that of each of the other pipes.

Sometimes it is possible to get good distribution of gases by the so-called down-flow type of precipitator. If the precipitator pipes are so arranged that heat can flow readily from the gas within the pipe to some substance without the pipe, the latter being kept considerably cooler than the former, a very even distribution of the gases may be obtained, but it must not be forgotten that the down-flow precipitators obtain their good distribution by a sacrifice of part of the heat energy in the gases, if reliance is placed on the difference in gas density due to a change in temperature.

The acid and moisture which is generally contained in the gases from smelters make their problems relatively easy from the standpoint of electrical precipitation, but it does not hold that a well-designed and well-constructed precipitator which proves highly successful in connection with one problem, can be installed at

another place in connection with another problem, and be equally successful. In fact, it might prove to be an utter failure, as can be readily realized from an examination of the statements preceding. It will also be obvious that brute force and sledge hammer tactics will not insure success. Patience and accurate deductions are more in order.

In installing a precipitation installation it would be disastrous to overlook the fact that the furnaces or other sources of the fume are of primary importance, and nothing should be done which will interfere with their operation. Similarly the draft requirements as to intensity and regulation should always be kept in mind. The flues should be so constructed that the draft drop through them is made very small, and if any draft drop is to be tolerated it should be concentrated at a point in the precipitators where it can do the most good, namely, across the orifices if this method of obtaining uniform distribution is used. A great deal of useful information in connection with the engineering problems relating to the design of flues, etc., may be obtained by a study of the work which has been done by the engineers responsible for the solution of large ventilation problems in factories and elsewhere.

In conclusion it might be mentioned that there are many plants in commercial operation on the continent of North America, several on the continent of Europe, in England, some in Japan, Africa and South America, and the work is growing very rapidly. There are perhaps 100 to 150 people devoting their entire time to the work and more are being added to the force as rapidly as they can be absorbed and trained. Standardization of the methods of handling problems, and the design of standard apparatus is progressing and the work is being more effectively organized. The precipitators are divided into two classes, viz., those which are designed and built on special order, and those which are designed and built as stock units.

Research Corporation,
New York City.

Standard Screen Scale for Testing Sieves.—The U. S. Bureau of Standards has just issued a statement recommending the general adoption of a standard screen scale in the interests of securing uniformity of usage. This scale was adopted by a conference, called by the Bureau of Standards of representatives of various committees of the American Society for Testing Materials, American Society of Civil Engineers, American Institute of Mining Engineers, American Foundrymen's Association, Mining and Metallurgical Society of America, American Waterworks Association, American Institute of Metals, and the American Spice Trade Association; also representatives of the Committee of Revision of the U. S. Pharmacopœia, the U. S. Geological Survey, the U. S. Bureau of Mines, the U. S. Bureau of Public Roads and Rural Engineering, the U. S. Office of Grain Standardization, and the U. S. Bureau of Standards; also representatives of a number of private firms engaged in industries which employ sieves. The screen scale adopted is essentially metric. The sieve having an opening of 1 mm. is the basic one, and the sieves above and below this in the series are related to it by using in general the square root of 2 or 1.4142, or the fourth root of 2 to 1.1892 as the ratio of the width of one opening to the next smaller opening. The first ratio is used for openings between 1 mm. and 8 mm., while the fourth root of 2 is used as the ratio for openings below 1 mm. to give more sieves in that part of the scale. The sieves are to be designated not by the number of meshes per unit length, but by the width of the opening in millimeters, as a 1.41 mm. sieve or a 0.36 mm. sieve.

Synopsis of Recent Metallurgical and Chemical Literature

Iron and Steel

Effect of Sulphur on Low-Carbon Steel.—At the recent annual meeting of the American Institute of Mining Engineers, in New York City, Prof. CARLE R. HAYWARD, of Massachusetts Institute of Technology, read a paper describing some experiments on the effect of sulphur in various steels. He refers to a previous paper by Dr. J. S. Unger, of the Carnegie Steel Company, in which the conclusion was reached from a long series of experiments that "the author does not advocate paying no attention whatever to sulphur content in steel, but believes firmly that a steel containing less than 0.100 per cent is not necessarily bad, and that it will show little, if any, difference in quality when compared with the same steel of much lower sulphur, other conditions being the same."

The conclusions reached by Prof. Hayward are as follows:

"The summary of the tensile tests shows that the high-sulphur steel has for each treatment the highest breaking load while the yield point ranks first for two treatments, second for three and third for two. From this we may conclude that the sulphur does not lower the tensile strength.

"The figures for elongation and reduction of area show that there is little difference in ductility between the low and medium-sulphur steels, but the ductility of the high-sulphur steel is slightly lower than the other two for most of the treatments.

"The average figures for the shock tests, except for the air- and furnace-cooled specimens, are highest for each treatment in the case of the low-sulphur steels and lowest for each treatment for the high-sulphur steels. The widest difference appears in the steels which have been quenched and reheated.

"It is difficult to draw definite conclusions from the results because of the newness of the shock test and the difference of opinion among engineers regarding its value. The tensile tests are not unfavorable to steels with moderate amounts of sulphur, while the shock tests show a decided falling off in strength as the sulphur increases. Until the interpretation of the results from the Charpy machine is more fully understood, it is impossible to say to which set of tests the most importance should be attached.

"Further light might be thrown on the subject by making alternate stress or fatigue tests. It would be important to learn whether the results would confirm the tensile or shock tests. Unfortunately, however, the stock of steels used in the previous work was exhausted, and whatever the results of the fatigue tests there would be an uncertainty in their interpretation because of difference in stock. It was, therefore, decided not to include this series in the present investigation."

Heat Treatment of High-Speed Tool Steel.—In a paper presented at the New York meeting of the American Institute of Mining Engineers, February, 1917, A. E. BELLIS and T. W. HARDY present a discussion and some results of experiments in treating high-speed tool steel in which metallographic means were used in determining the correct hardening temperatures. The authors state that in order to be on the safe side the average tool hardener uses a temperature much too low to give the best results with the high-speed steel he uses. In the case of cutters which are finished to a given diameter before hardening, it is impossible to grind the tool after hardening, so that it is essential that the surface be protected from oxidizing or decarbonizing.

The analyses of the steels used in the tests are as follows:

	C. Per Cent	W. Per Cent	Cr. Per Cent	Va. Per Cent
A	0.58	17.4	3.11	1.14
B	0.60	13.3	3.32	3.58
C	0.53	13.0	4.89	2.45
D	0.75	17.7	3.30	0.85
E	0.60	16.5	3.55	0.70

Six specimens from the same bar of each kind of steel were hardened from different temperatures, and photomicrographs made. The six samples were taken from the same bar in the annealed condition regularly furnished the tool maker. Photographs were made of the longitudinal section, care being taken to grind off the outer surface. The specimens, $\frac{1}{4}$ -in. square in section, were first preheated at 1500 deg. Fahr., and then quickly placed in the high-speed furnace already heated to the desired temperature, left at this temperature for 1 min. and quenched in oil. The temperature was controlled by a standard pyrometer, consisting of a rare-metal couple and potentiometer. An optical pyrometer of the Holborn-Kurlbaum type gave excellent checks with the standard pyrometer, and proved more convenient and durable. A precision of 10 deg. Fahr. was attained throughout. The polished specimens were etched for 15 min. in 4 per cent alcoholic solution of nitric acid, and photographed.

In general, the steels that show some excess carbide even at the maximum hardening heat are the most efficient. These, as a rule, are the steels with high tungsten content; they harden from a higher temperature and over a wider range than the lower-tungsten steels. For this reason they do not require as careful treatment and are, therefore, more popular than the lower-tungsten steels. The steels with lower tungsten and higher vanadium give better results when hardened at the lower temperatures than do the higher-tungsten steels when these are hardened at the same low temperatures, but the comparison is not so advantageous to the lower-tungsten steels when the steel with higher tungsten is given the proper hardening heat.

The importance of carefully controlling the hardening temperature, and of varying it for the particular steel used, cannot be overemphasized. The custom of using one "high-speed temperature" for all tools is very poor practice, for, as shown by the photomicrographs, the best structure may be obtained with one steel at a temperature which will "burn" another, or not harden a third. Thus 2300 deg. Fahr. or over is necessary to give A or E a good structure, but this temperature gives a coarse grain in the other steels, or "burns" them. Again, a temperature as low as 2150 deg. Fahr. can satisfactorily harden B or D, but tools made of other steels would not stand up if hardened at this temperature. More extreme examples could have been shown, but the samples chosen are typical of the most widely used brands of high-speed steel.

The average hardener rarely obtains the best result from his steel. The reason for this is, especially in the cases of tools that cannot be ground after hardening, that oxidation becomes a serious problem at higher temperatures. The use of a barium chloride bath to eliminate this difficulty has the disadvantage that the surface of the tool becomes decarbonized. A method that has proven satisfactory is to place the tools after preheating in the reducing atmosphere of a carbon resistance electric furnace already heated to the required temperature. The very short time necessary to get the tool to the temperature of the furnace eliminates deleterious surface effects. Pack hardening often gives good results but, owing to the great affinity of iron for

carbon at high temperatures, care must be taken to reduce this carbonizing action to a minimum. This may be done by selecting a packing material of little or no carbonizing power, and by cutting down the time during which the metal is in contact with the packing material.

The increased efficiency and cutting power of tools that have received the proper heat treatment is out of all proportion to the time given to the study of the particular steel involved, and to the care given the work.

Seasoning of Castings.—In a paper presented at the New York meeting of the American Institute of Mining Engineers in February, RICHARD MOLDENKE, of Watchung, N. J., discusses the "seasoning" of castings. He states that it is one of the little-known characteristics of cast iron, which nevertheless has an important bearing on results where accuracy in machining is essential. It is the ability of this material to ease up internal strains when allowed to remain quiescent for a more or less extended period of time. It seems as if the molecules in such a casting, by virtue of their "mobility," can adjust their relative positions to an extent sufficient to overcome some of the existing stresses.

Every engineer knows the danger of water-hammer in pipe lines, particularly if the latter are of cast iron. Every mechanic knows, or should know, that it is not good to strike a fitting that is under steam pressure. The author discusses the two kinds of reduction in volume in a casting, viz.: that due to the change from the liquid to the solid state, and the reduction in volume after setting until ordinary temperatures have been reached. He discusses seasoning as follows:

"Every mechanic knows that in planing up a slab of cast iron on both sides to get a true job it is necessary to take a light cut, reverse, and take a cut on the other side, then reverse again for the finishing cut, finally reversing for the last cut. If this is not done there will be warped surfaces to deal with on account of the internal strains. Again, it is well known that to get a true piston is a rather difficult matter. Even after grinding to a finish it is apt to get out of true. It is not so generally known, however, that if such a cast-iron plate or piston is allowed to remain in storage for a long period, the results will be much more satisfactory. The castings have "seasoned." Where establishments are familiar with the situation, orders for castings are placed far ahead of requirements. Since, however, on getting to the bottom of a big pile the difficulty of tracing defective work becomes correspondingly harder, only shops having their own foundries are likely to do much storing. The present demand for very high-class machined castings, as evinced by automobile cylinders, pistons, engine and compressor cylinders, etc., should bring this question of 'seasoning' out very prominently. Inquiry by the writer has shown but little knowledge on the subject in the trade generally, though where first-class foundrymen were connected with the industries involved, these were very much alive to the matter. In general, the difficulty seems to be the inability of storing up ahead, or when so doing of striking defective product when least expected, particularly in such cases as castings for piston rings, etc. For what seems the best indirect explanation of the 'seasoning' action, we are indebted to the well-known metallurgist, A. E. Outerbridge, Jr., who in his famous experiments on 'tumbling' castings to increase their strength, found that by the action of light blows, often repeated, the internal strains were relieved to such an extent that the real value of the metal came into play. The 'mobility' of the molecules

was aided by artificial means. Incidentally, however, the tests establish the 'mobility' of the molecules in cast iron very satisfactorily. Replace half-an-hour's tumbling by 6 months' quiescence and the molecules will have done their work with somewhat the same results. In view of the possible depression scheduled for this country on the close of hostilities in Europe, would it not be well to ease up operations slowly instead of shutting down tight. This would help the industrial situation adjust itself more safely and at the same time stock up supplies of castings which will be all the better for having seasoned. Inasmuch as similar improvement has been noticed in the case of ingots, billets and other iron-base products, the same argument would hold. The writer presents this memorandum in the hope that a discussion may bring out present practice and possible applications with respect to an almost unknown but highly valuable characteristic of cast iron and allied materials."

Effect of Time in Reheating Hardened Steel.—At the recent New York meeting of the American Institute of Mining Engineers, Prof. CARLE R. HAYWARD and S. S. RAYMOND, of the Massachusetts Institute of Technology, read a paper describing some experiments on reheating hardened steel below the critical range. The experiments were made with the object of finding the effect of time on reheating. The steels used were practically all of the same composition, the average analysis being, C, 0.45 per cent; Si, 0.03 per cent; Mn, 0.49 per cent; Mn, 0.54 per cent; P, 0.015 per cent. The specimens were heated first to 800 deg. C. and then reheated in sets of three for 15 minutes, 30 minutes, one hour, two hours and 4 hours, at 300 deg. C., 400 deg. C., 500 deg. C. and 600 deg. C. An electric resistance furnace was used. After the heat treatment the specimens were tested in an Olsen machine for tensile strength and were also tested for hardness. Microscopic examination of the specimens did not show enough difference in the various samples to make their reproduction of interest. The results indicate that for reheating quenched medium carbon steel to temperatures below 500 deg. it is only necessary to heat it through. Longer heating has little or no effect on the tensile strength, ductility or hardness. At temperatures above 500 deg. increasing the time of treatment causes a slight falling off in hardness and tensile strength with a corresponding increase in ductility. Curves constructed from the results show that for the 15 minutes heating the ultimate strength falls about 25 per cent and the yield point about 20 per cent as the temperature increases from 300 deg. to 600 deg., and the same figures hold approximately true for the one-half hour, one-hour and two-hour treatments. Heating for four hours causes the ultimate strength to fall about 30 per cent and the yield point about 25 per cent as the temperature increases from 300 deg. to 600 deg.

Strontium

Production of Strontium in the U. S.—In the *Mining and Oil Bulletin* (Los Angeles Chamber of Mines and Oil) for February, 1917, B. W. JAMES presents some data on the production of strontium ore and compounds in this country. He states that it was not until after the first year of the European war had elapsed, and a shortage of the nitrate developed, that the attention of our chemists was called to the fact that Germany had been our sole source of supply while we had workable deposits of ore as yet undeveloped. In April, 1916, the price per pound was suddenly boosted to 54 cents as against the 6½ cents prevailing some months earlier. The largest consumers are the fireworks and railway fuse manufacturers. A quick scout-

ing for material showed that the only workable deposits were of the sulphate, or celestite, in Arizona and California, and incidentally that such deposits were inconveniently located in desert countries far from transportation. In the past few months some nitrate has been made from ore from an isolated deposit in San Diego County with a 40-mile wagon haul. There is also a very promising deposit in the Avawatz Mountains, but at present is too far away for operation. Another deposit, 15 miles south of Gila Bend, Ariz., was placed within 2 miles of a shipping spur by the completion of the Calumet & Arizona's new railroad to the Cornelia properties at Ajo. The chief associated ingredient is silica, which is inert and harmless. Some ore has been sold during the past year and it is expected that much more will be used, as several companies have negotiated for a supply. However, the owners look forward to a great demand following the adoption of the strontia process in the manufacture of beet sugar, which effects a saving of 6 per cent to 8 per cent of the saccharine content of the molasses over the methods employed at present. The Geological Survey reports that Germany and Russia each use 100,000 tons per year of strontium hydroxide for this purpose and that the process is also applicable to cane sugar. The German supply is obtained from the carbonate, strontianite, which may be calcined to a caustic condition similar to quicklime, being then in a condition to use in the extraction of sugar. The indications are that this ore supply is diminishing and that celestite will later be used to some extent. Contrary to various reports, strontium is not used in the manufacture of high explosives, although much of the nitrate is used in "tracer shells" and by the various navies in signals.

Recent Chemical and Metallurgical Patents

Nickel

Extraction of Nickel in Electric Furnace.—A process for producing nickel, or ferronickel from garnierite, a hydrous nickel magnesium silicate, is patented by MICHAEL A. REBERT of York, Pa. The furnace design presents no unusual features. It is cylindrical and vertical with a rounded bottom and having one top and one bottom vertical electrode. Metal and slag spouts are provided in the proper places. Calcium fluoride is first charged into the furnace and melted by striking an arc. The garnierite or other ore to be used is then gradually added and is melted and becomes mixed with the calcium fluoride. The current liberates fluorine at the anode from the calcium fluoride, and this combines with the silicon of the ore, liberating the nickel. The calcium is constantly renewed, the nickel is tapped from the bottom of the furnace and the slag from near the center. To liberate the fluorine at the anode, a direct current must be used, though it is stated that alternating current also gives good results, no complete explanation being given. (1,215,857, Feb. 13, 1917.)

Quartz Glass

Manufacture of Quartz Glass.—Simplifications in the method of manufacturing quartz glass are described in a patent of OTTO C. TRAUTMANN of New York City, which he has assigned to the Sidio Company of America, of New York City. Formerly in producing quartz glass objects it has been necessary to introduce a blast of air into the interior of the plastic quartz body before it has had a chance to cool. This required the introduction of pipes and apparatus in the interior of the furnace which is impractical, due to the extreme heat. The present invention has for its object to devise a process whereby the vessel may

be blown without any special apparatus and without requiring any handling, involving loss of time. In carrying out the process, the quartz is first fused in an electric furnace consisting of a shell 10 lined with suitable heat-resisting material 11. The base of the furnace is closed by a conductor 12 and at the top of the furnace is a conducting head 13 between which is positioned the resistance core 14. The latter is reduced in section as at 15. The quartz sand is introduced into the furnace, the resistance core is properly clamped in place and the current turned on. The plastic mass of quartz 17 soon forms about the core. When the requisite amount of plastic is formed, a door 18 at the bottom of the furnace is opened, permitting the surplus sand to escape. The two movable parts 19 and 20, having a concavity 21, 22, are actu-

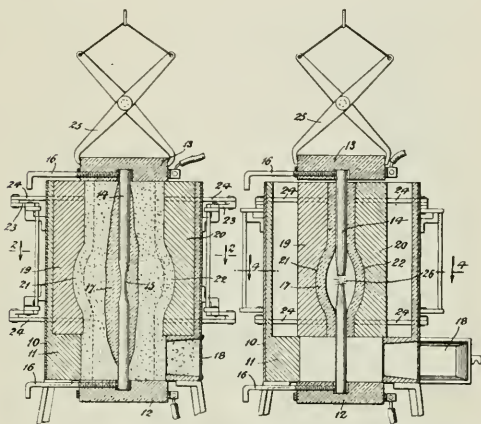


FIG. 1—QUARTZ ELECTRIC FURNACE

ated by levers 23 and rods 24. The concave portions 21, 22 form a mold about the plastic as illustrated in the right-hand section. It is now necessary to produce an interior pressure so as to expand the plastic into the mold. This is accomplished as follows: The upper portion of the resistance core 14 may be twisted or strain otherwise applied, as by means of the tongs 25, so as to break the core at the weakened portion 15. The portions of the core may then be separated slightly, forming an arc 26, as clearly appears in the right-hand illustration. The gases generated by the arc then produce a pressure sufficient to force the plastic into the mold. (1,215,433, Feb. 13, 1917.)

Polishing Iron

Composition for Polishing Iron.—A metal polish for removing rust, etc., from iron is patented by MATAICHI YASUDA of Koishigawa, Tokyo, Japan. An example of the composition of this powder is as follows: powdered metallic aluminum 2 parts by weight, dehydrated alum 3 parts, finely powdered crystalline silica 5 parts. The powder is applied to a water-soaked cloth and rubbed steadily on the surface of the iron to be cleaned and polished. The polished surface is then wiped off, and water and suitable grease applied to preserve the polish. (1,216,643, Feb. 20, 1917.)

Ferroalloys

Electric Furnace.—An electric furnace especially suitable for melting ferroalloys is patented by HECTOR DE NOLLY of St. Chamond, France. The patent is assigned to the Société Electrometallurgique de St. Beron of Lyons, France. A cross-section of the furnace

the classifying action, or in other words all products, regardless of the gravity, have more of an equal chance to escape from the mill.

3. Thick pulp in a mill, as 30 per cent water and 70 per cent ore, increases the efficiency of the mill, for the liners of the mill and the balls or pebbles become coated with particles of ore and wherever there is contact, crushing is produced, this tending to increase rapidity of grinding and decrease wear on steel and pebbles. It is not possible to use such high consistencies or such thick pulp in pebble mills with overflow trunnions, for at this consistency small pebbles will float and discharge from the mill unless there is a screen or grate to keep them in.

4. Finished pulp in a mill or ore which has been reduced to the required fineness should be discharged at once. If it remains in the mill after being ground to the required fineness it not only retards the actions of the balls for useful work, but the mineral is subjected to unnecessary sliming action. For this reason as it costs but little to separate the finished from the unfinished product outside the mill it is better to do this and return oversize rather than to attempt to finish the crushing in one pass. One pass crushing is, therefore, inefficient both because of the loss of work in overcrushing and the unnecessary sliming of mineral.

5. Whether we use Rittinger's or Kick's law the work to be done becomes very much greater as we crush finer and wherever there are particles or ore that come in contact with the metal points work in crushing is produced. Therefore, theoretically the mill should increase in diameter as the ore advances through the mill in order that the crushing energy be increased as required for the work to be done.

6. That in crushing in a closed circuit for fine sizes as floatation or all sliming for cyanide the fineness is determined by the overflow of the classifier and when crushing in such a manner with graded balls, and coarse ore that forms a compact and flexible mass, the length of the mill has nothing to do with the fineness of the product.

7. The rapid removal of a finished product from the mill when crushing in a thick pulp depends upon the difference of head between the intake and the outlet and the amount of pulp contained in the mill. Mills that overflow at the trunnion are necessarily slow in discharging their entire load on account of the large quantity contained within. Such mills are like a mill dam in a flowing stream.

8. That in taking primary crusher product and feeding to a ball mill making a product passing $\frac{1}{4}$ in. mesh or 60 mesh is effective and efficient. As to the relative efficiency between this and two or three stage crushing is a matter of space, of capacity, of flexibility and cost of crushing the material. If power, liners, balls and labor cost nothing it would make very little difference what type of mill was used or the number of stages adopted in crushing.

Now the Marcy mill is designed for crushing coarse ore taking a primary feed, say 3 in. or 4 in., and crushing it all through $\frac{1}{4}$ in. or $\frac{1}{2}$ in. with one pass of the mill. It is designed also to take the same feed and crush it through 20 x 30 mesh when operating in closed circuit with a screen or hydraulic classifier. When taking this coarse feed and operating in closed circuit with a mechanical classifier, as the Dorr, it will crush so all will pass through 50 or 100 mesh. The mills are shorter than the diameter. A number 86 mill is 8 ft. in diameter and 6 ft. long. A 64½ mill is 6 ft. in diameter and 4½ ft. long, etc. Various types of liners have been used, but in general the mills are equipped with Krupp type made of manganese steel. The entire discharge end

is fitted with grates made of grizzly bar section. The spacing or the discharge of the ore is set for 3/32, $\frac{1}{8}$ or 3/16 in., depending on what product is desired. Back of the grates and next to the discharge end radial lifters carry the pulp up and discharge it through the trunnion. Thousands of dollars have been spent in the development of this grate. It is made of rolled, high-carbon, tempered chrome steel. The spacing for the passing of ore is maintained by small pads that are on the bars themselves and are placed during the last pass of the rolls when the bars are made. There is a slight bevel to the grates toward the discharge end so that the sand will not clog in passing. In the actual operation of the mill the pulp line is about $\frac{1}{4}$ of the diameter of the mill. The height of this pulp line is maintained by the amount of water entering the mill. A very slight turn of the water valve will raise or lower the pulp, more water lowers the pulp line and thick pulp has the opposite effect. It would seem that any mechanical device for fixing the pulp line is superfluous and shows a lack of knowledge regarding the actual requirements.

In a short time there will be treated over 50,000 tons ore daily with Marcy mills, working under various conditions. Among the most notable installations are the Kennecott Copper Corp., the Braden Copper Company, the Doe Run Lead Company, and the Inspiration Copper Company. I mention these, as they are all typical and the mills are one size. The mills are equipped with 3/16 in. grate or opening between the bars and when operated so that the ore passes the mill only once they have had a capacity of 1100 dry tons per 24 hours each, taking coarse feed. Other mills with coarse feed and operating in closed circuit with a Dorr classifier have crushed in an excess of 500 tons per day each, with 3 per cent on 48 mesh.

The entire end of the Marcy mill is covered with a grate and the actual area of the actual 3/16 in. openings in the grate for the ore to pass is 1100 square inches. The inside diameter of the trunnion is 12 in. and the area is 113 square inches, consequently we have the grate discharge area nearly 10 times that of the trunnion discharge area. I am of the impression that the discharge is not restricted. The grates, as now manufactured, tempered and held securely in place, do not blind and the ore at all times when reduced to the proper fineness discharges freely.

At the Inspiration mill, when treating 500 tons per day of the original feed, there is approximately 1600 tons that pass the grate, due to the circulating load. The 36 mills that are now in operation at Inspiration have a daily capacity of 17,000 dry tons per 24 hours. There are no other ball mills or pebble mills in use at this plant. As noted, there will be installed shortly two cone mills that were furnished the Inspiration Company without cost under the guarantee that they would have an equal capacity as the Marcy mill and do an equal amount of work within very much less horsepower. Whether these cone mills come up to their guarantee remains to be seen.

Since the installation of the Marcy mill at the Magna Copper Company, the Inspiration Company and the Utah Copper Company, my design has been copied and appropriated by a number of manufacturers without my consent. The system of crushing advocated by me at the Inspiration plant has been extensively used since its installation and success, and I hope it will prove all that is expected of it. We are now endeavoring to simplify and improve this mill wherever possible. This necessarily means a vast amount of experimenting and the cost is large to the companies who are carrying on these experiments.

We have designed liners for the shell that are made in

solid pieces. They are like a large roll shell, 8 ft. in diameter and 6 ft. in length and 5 in. in thickness made in manganese steel. We have designed, and it has been adopted as standard, a one piece end liner made of manganese steel and weighing 2½ tons. Such liners and such pieces can only be handled in big installations where they have the services of a traveling crane and where the mill can be knocked down to receive these parts. We expect the future liners and grates at Inspiration to last nine months of continuous service. We are endeavoring to increase the efficiency of the mechanical classifier and to increase the efficiency and effectiveness of the balls themselves, hoping to satisfy the operator whose problems are capacity, costs and metallurgical results. In my opinion this type of mill has come to stay, for its principles are in accordance with the fundamentals of wet crushing.

RESULTS OF MILLING DURING THE MONTH OF AUGUST, 1916, AT THE
INSPIRATION CONSOLIDATED COPPER COMPANY
Details of screen analysis.

	Feed to Ball Mills	Product
On 1.5-in.	17.7	
On 1-in.	16.5	
On ¾-in.	24.7	
On 3 mesh	7.3	
On 6 mesh	7.7	
On 8 mesh	2.2	
On 14 mesh	4.8	
On 28 mesh	3.6	
On 48 mesh	2.9	2.9
On 65 mesh		7.9
On 100 mesh	2.3	12.6
On 150 mesh		12.6
On 200 mesh	1.5	5.8
Through 200 mesh	8.8	58.2
	100.0	100.0

The kilowatt-hours required per ton ore increase grinding, conveying and sampling. 0.409

The number of kilowatt-hours required per ton ore in fine grinding in Marcy ball mills, divided into the following:

Power for conveyor, D. 0.18

Dorr classifier and cranes. 0.18

Power for Marcy ball mills. 9.68

Average tonnage ore ground per Marcy mill in 24 hours. 9.86

Fumigating Baled Cotton by the Hydrocyanic Acid Gas Process

Since the revision of the rules and regulations which govern the importation of cotton lint into the United States, effective Feb. 1, 1916, the fumigation of imported cotton has become a live industry. Among the companies organized to enter this new field The Vacuum Company, incorporated under the laws of Massachusetts, was the first to get its plants in actual operation, having one plant in Somerville, Mass., and another in Brooklyn, N. Y.

The object of the disinfection of cotton is to destroy the larvæ of the ping boll worm, which is a native of

India, the Orient and Hawaiian Islands. The eggs which it deposits in cotton seeds hatch to life and feed on the seeds for a period as long as seven months. The present cotton disinfecting plants are built to carry out the method of disinfection prescribed by the Horticultural Board of the Department of Agriculture on March 22, 1916. This method, briefly stated, requires that the unmanufactured cotton and cotton waste must be placed in a suitable fumigating chamber where it is subject to hydrocyanic acid gas under certain definite conditions.

In generating the gas lumps of cyanide of sodium are placed in a steel basket in the mixing tanks and dissolved in the proper amount of water. This solution is then raised from the mixing tank to the cyanide measuring tank by vacuum. Sulphuric acid is then drawn directly from the carboys, also by vacuum, and the two liquids in the proper proportions are introduced into the generators where their union causes the formation of hydrocyanic acid. The gas thus formed passes from the generators through cartridges of cyanide of sodium and limestone to absorb completely any free sulphuric acid. It is then drawn into the retorts. After the gas has been used in fumigation it is pumped out of the retorts and passed through a spray washing machine, where it is broken and the cyanide replaced. Two large vats, containing caustic soda solution, are used in connection with this reclamation, one being used until it has been saturated, when the process is transferred to the other vat. Continuous circulation is maintained through the spray washer while pumping out the gases.

To fumigate the cotton, all bales after being trucked by hand from the freight cars on the sidings to the platform cars are moved into the retorts and the doors and gates closed. The retorts are then subjected to a vacuum of 25 in., after which the hydrocyanic gas is introduced until the vacuum is decreased to 5 in. This condition is maintained for one and a half hours, when the gas is again exhausted to a 25-in. vacuum; then after sufficient washing with air to eliminate any danger of escaping gas the cotton is removed from the retorts, sorted and reloaded on cars for shipment.

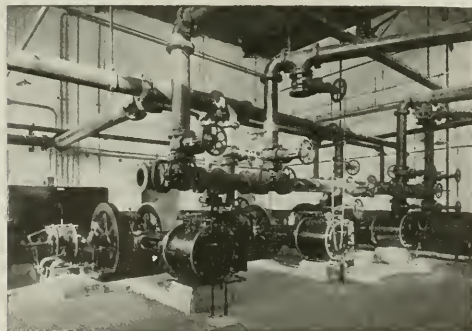
In operating the cylindrical retorts the platform cars are loaded alternately from either end, so that while one train of cars is being unloaded and loaded again, another loaded with cotton is in the retort being fumigated. These retorts permit a very efficient and time-saving system of handling. The entire layout of vacuum pumps and piping is such that any combination of pumps and generators may be used on any or all the retorts at one time.

The Brooklyn plant of The Vacuum Company is operated in the same manner as the one in Somerville, Mass. It is of smaller capacity, containing one rectangular retort 42 ft. long. An additional retort and pump are, however, being installed at the present time so that the capacity of the plant will soon be doubled.

Studies, plans and specifications for both Somerville and Brooklyn plants of The Vacuum Company were prepared by Charles T. Main, engineer, of Boston, Mass. Herbert L. Sherman of the New England Bureau of Tests, Inc., and Arthur D. Little, Inc., acted as consulting chemists.

A New Flotation Machine

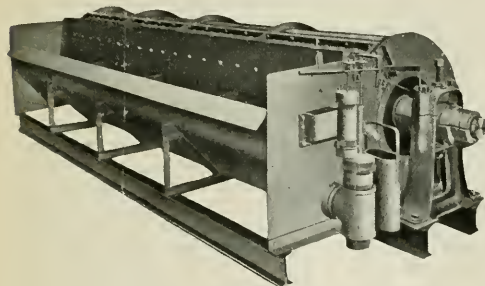
The K & K Flotation Machine, made by the Southwestern Engineering Co., Los Angeles, Cal., consists of a cylindrical housing about 10 ft. long and 30 in. in diameter, as shown in the accompanying illustration. To the front part of this is attached a "V"-shaped compartment called the frothing-chamber. The frothing-



VACUUM PUMPS AND PIPING FOR FUMIGATION OF COTTON

chamber is provided with a lip, over which the concentrates are discharged into a suitable launder.

Inside the cylindrical housing or aeration-chamber is located the rotor which consists of a 3 7/16-in. steel shaft, on which is mounted four pressed steel spiders, which carry the lagging and riffles of the rotor. The rotor is supported by two main bearings located at each



K & K FLOTATION MACHINE

end of the machine. The lagging forming the periphery of the rotor is so spaced as to leave a 1/4-in. opening or slot between each piece—there are 16 of these pieces and each piece is provided with four hardwood riffles, which run the entire length of the rotor which is about 10 ft. long. The rotor revolves at 180 r.p.m. and has a clearance of 3/8 in. between its outside periphery and the inside surface of the aeration-chamber.

The shaft on which the rotor is mounted passes through the two end plates of the machine by means of two air ducts 14 in. in diameter and 13 in. long. These air ducts are ample size to furnish all the air from atmosphere necessary to thoroughly aerate the pulp as it is revolved between the outside riffled surface of the rotor and the inside surface of the aeration-chamber. There is no leakage of pulp through these air ducts, and there is a continuous influx of air from the atmosphere. This influx of air is discharged by centrifugal force through the air slots between each of the 16 pieces of riffled lagging forming the periphery of the rotor and immediately comes in contact with a thin film of pulp which has been circulated by the revolving rotor.

The frothing-box is provided with suitable partitions and openings which cause (together with the level control device), the skimming of a thin film on the surface of the riffled rotor. This thin film is supplied with air which passes in through the air ducts at each end of the machine and out through the air slots of the rotor, coming in contact and thoroughly aerating the revolving pulp in the space between the outside periphery of the rotor and the inside surface of aeration-chamber.

The pulp enters at one end of the machine and is discharged at the opposite end, while passing through the machine a distance of 10 ft., it is also caused to revolve through the aeration-chamber. This longitudinal and rotary action causes the feed to move in the path of a helix during which course it is thoroughly aerated, forming a froth which carries the mineral, and discharges same over the lip of the frothing-chamber, while the tailings are discharged at the other end of the machine. An adjustable level control device is provided which maintains the proper level of pulp in the machine, which in return furnishes the correct height of the bubble column in the frothing-chamber.

As can be seen from the above description, the feed enters at one end of the machine, the tailings are discharged at the opposite end, while the concentrate is discharged over the lip of the frothing-chamber into a

suitable launder. The machine, therefore, is a complete unit in itself, receiving the pulp at the intake, aerating and frothing same, discharging concentrates over the lip of the of the frothing-chamber, and finally discharging the tailings at the opposite end of the machine. All this is carried on in one operation, which is continuous, the machine itself furnishing a horizontal and circular path for the feed, during which aeration takes place, frothing is produced, and tailings and concentrates are discharged.

The steel machine is constructed of No. 10 steel plate, with end pieces of 1/4-in. plate mounted on a structural steel base composed of three 5-in. I-beams, on which are fastened the two main bearings. The housing over the rotor is constructed of rolled plate re-enforced with angle bars, and is so arranged that it can be removed for the replacing of the hardwood riffles which last from four to six months. The steel machine is recommended for feeds which contain no excessive acid which might be detrimental to such construction, and in cases where excessive acid is present wooden type is provided. This machine is built in the same general design, being entirely of wood, with the exception of the shaft, spiders and bearings.

Each machine is provided with a pulley for driving from a line shaft, but may also be driven by direct connection to electric motor or other power.

The machine is a complete unit, requiring no blower, air compressor nor pre-agitation. The floor space required is 4 ft. by 14 ft., and the head room about 3 ft. The capacity of the machine is 80 to 150 tons per 24 hr., and requires from 8 to 10 hp. to operate. The weight of the steel machine is 3500 lb., and the weight of the wood type is 2500 lb.

Automatic Temperature Control

The Bristol Company of Waterbury, Conn., have developed a new line of automatic temperature controllers for gas, oil fired and electrically heated furnaces. The principle of operation of these controllers is to employ three elements: the measuring element, the contacting element, and the operating element.

The measuring element may be any type of pyrometer or thermometer.

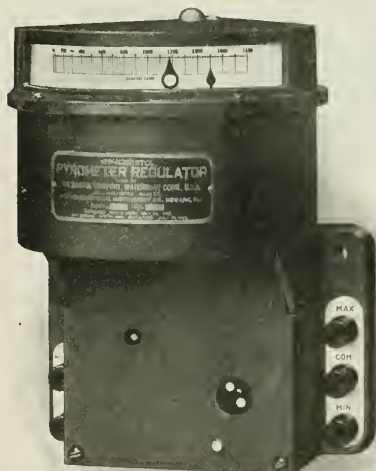


FIG. 1—EXTERNAL VIEW OF THERMO-ELECTRIC TYPE

The controlling element is combined with the measuring element and consists primarily of a patented electrical contact closing device which operates at predetermined high and low temperatures, and by means of this electrical circuits are closed or opened, thus energizing or disconnecting the operating element.

The operating element consists of the device which actually regulates the heat supply in the furnace, as,

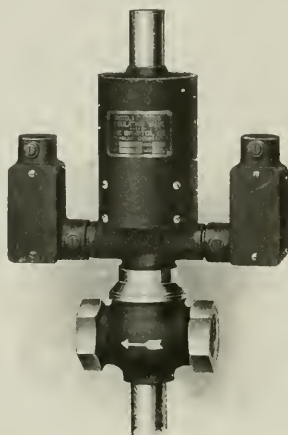


FIG. 2—GAS AND AIR VALVE

for instance, in the case of a gas-fired furnace, a pair of electrically operated gas and air valves, and in the case of an electric furnace it consists of a special relay switch opening and closing the circuits of the heating element of the furnace.

Fig. 1 shows an external view of the measuring and controlling elements of the thermo-electric type. The indicating arm is completely insulated from the operating circuits and the contacting device is frictionless. These controllers are made for all temperatures up to

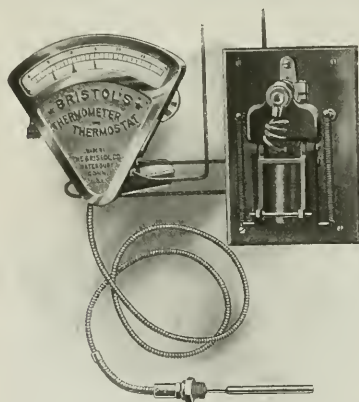


FIG. 3—VAPOR TYPE THERMOMETER-THERMOSTAT

3000 deg. F. and with high-resistance movements for use either with base or precious metal couples.

Fig. 2 shows one of the special gas and air valves, two of which are used in connection with gas furnaces if air is supplied at a pressure, and both gas and air valves are operated simultaneously so as to insure having the proper mixture at all times.

Fig. 3 shows one of the vapor-type thermometer-thermostats, with sensitive bulb and connected to the special relay switch employed for adapting these instruments to the control of temperatures in electric ovens and furnaces.

Book Reviews

The American Petroleum Industry. Vols. I and II. By Raymond Foss Bacon, Ph.D., and William Allen Hamor, M.A. Price, \$10. New York: McGraw-Hill Book Company.

This is a most interesting and important contribution to the literature on petroleum by the director and assistant director of the Mellon Institute of Industrial Research of the University of Pittsburgh. In conjunction with their work other specialists in specific fields have been called upon to write particular chapters for which they are best qualified. They are F. G. Clapp, E. E. Greve, Roswell H. Johnson, J. P. Cappeau, and L. G. Huntley.

In the preface to their work the authors state their purpose to be "to produce a treatise which would present a comprehensive survey of the American petroleum industry, distinctly modern in every respect, and suitable not only as a general reference work for those engaged in the industry, but also as a text-book for students of petroleum engineering. For these reasons, the subject matter is essentially descriptive, without, however, omitting the theoretical considerations necessary for the proper understanding of the subjects included."

The subject has been taken up in the following order: Chapter I—The Geochemistry of Petroleum.

Chapter II—The Geology of Petroleum (by F. G. Clapp).

Chapter III—The Distribution of Petroleum in the United States.

Chapter IV—The Physical and Chemical Properties of Petroleum.

Chapter V—The History of the Petroleum Industry in the United States.

Chapter VI—Oil Well Technology.

Chapter VII—The Valuation of Oil Properties (by Roswell H. Johnson).

Chapter VIII—Some Commercial Factors Involved in the Appraisal of Petroleum Properties (by J. P. Cappeau).

Chapter IX—Possible Causes of the Decline of Oil Wells and Suggested Methods of Prolonging Yield (by L. G. Huntley).

Chapter X—Efficiency in the Production of Petroleum (by Roswell H. Johnson).

Chapter XI—The Condensation of Gasoline from Natural Gas.

Chapter XII—Refinery Technology.

Chapter XIII—Special Refinery Technology.

Chapter XIV—Refinery Engineering.

Chapter XV—Hygienic Considerations.

Chapter XVI—Some Problems of the Petroleum Industry.

Chapter XVII—The Shale-Oil Industry.

Chapter XVIII—A Glossary of Bitumenology.

The chapter on the geochemistry of petroleum summarizes the various theories of the inorganic and organic origin of petroleum in a clear-cut manner. The general conclusions as to our present state of knowledge follows: "Nearly all of the proposed theories to account for the origin of petroleum include certain elements of truth; in regard to some of the theories, considerable experimental proof has been forthcoming. Sokolov's cosmic hypothesis is sustained by the fact

that hydrocarbons are found in meteorites. The volcanic hypothesis is supported by the fact that hydrocarbons occur among volcanic emanations. The organic origin of petroleum, however, seems to be best maintained by the geological relations of the hydrocarbons. On the whole, the Engler-Hofer dual theory has the largest number of adherents, to whom the evidence seems to be clear that no important petroleum field derived its hydrocarbons from purely inorganic sources."

David White has considered the ingredient materials of coals and oil rocks, the biochemical and dynamo-chemical processes of alteration of the organic detritus, its devolatilization, its regional alteration and the corresponding regional differences in petroleum, and the occurrence of higher rank oils in regions of greater alteration of the carbonaceous residues. His conclusions are as follows: (1) Petroleum is a product generated in the course of the geodynamic alteration of deposits of organic debris of certain types buried in the sedimentary strata. (2) The quantity and characters of the oils generated are determined by (a) the composition of the organic deposit at the beginning of alteration; (b) the stage in the progress of this; (c) the elimination of the heavier and more viscous hydrocarbons through filtration incident to migration. It is probable that the composition of the mother organic deposit largely regulates the types of oils; it may account for the nitrogen and sulphur content, color, etc. (3) The rank of the oils is proportional to the degree of alteration of the carbonaceous deposits. (4) The change is marked by concentration of hydrogen in the distillates and of carbon in the residues. (5) Abnormally light oils are in most cases due to filtration. (6) In general, the oils found in successive underlying formations are progressively higher in rank. (7) In regions where the progressive devolatilization of the organic deposits in any formation has passed a certain point (usually 65-70 per cent fixed carbon) commercial oil pools are not present in that or underlying formations, although gas may occur. (8) Wherever the regional alteration of the carbonaceous residues passes the point marked by 65-70 per cent of fixed carbon in the pure coals, the light distillates appear in general to be gases at rock temperatures.

Campbell, who has considered the available evidence in a searching manner, states that this testimony favors the animal origin of most petroleum, although a certain amount has probably been derived from the fatty portions of plants. Some authorities contend that oils having an asphalt base are derived from animal matter and oils having a paraffin base from vegetable matters. Still other adherents of the organic theories claim that the differences in quality of the oils are due to differences of capillarity, heat, pressure, extent of migration, etc., but none of these theories seems to have been proved.

Richardson has recently expressed the opinion that the phenomena of surfaces and films, as demonstrated by the recent developments of colloidal chemistry, open up an entirely new point of view for the interpretation of the origin of petroleum and asphalt, and one which will be, no doubt, widely developed in the future. It seems to Richardson that the origin of all forms of petroleum must be attributed to surface action between a natural gas and the "sands," using this term in a general sense, with which it comes in contact.

The chapters on "The Distribution of Petroleum in the U. S.," "The Physical and Chemical Properties of Petroleum" and "The History of the Petroleum Industry in the United States" summarizes quite thoroughly the condition of these three phases of petroleum. "The History of the Petroleum Industry" is especially fas-

cinating in showing its development from distribution in ounce bottles of crude petroleum for medicinal purposes to the giant industries summarized in the companies of the Standard Oil group; the authors give the various companies, the date and place of incorporation, their capital stock, and the type of marketing for each company and the ownership of various pipe lines.

The chapter on "Oil Well Technology" is profusely illustrated with clear cuts pertaining to drilling methods and appliances.

The chapter on "The Valuation of Oil Properties," by R. H. Johnson, gives an excellent outline of the logical method of procedure in the valuation of oil lands.

L. G. Huntley has contributed an important chapter on the "Possible Causes of the Decline of Oil Wells and Suggested Methods of Prolonging Yields." He summarizes this decline under the following heads:

1. Formation of waxy sediments that obstruct the passage of oil from the sand.
2. Decline of gas pressure in the district; that is, decrease of expulsive force, due to the exhaustion of the lighter and gaseous hydrocarbons.
3. Decrease in quantity of oil draining by gravity down the dip into the area affected by a well.
4. Decrease of the oil supply within the drainage area of a well on account of near-by development or the original limits of the pool.
5. Flooding by non-encroaching salt water under low pressure.
6. Flooding of the productive formation by salt water under high pressure.
7. Flooding by fresh water from the surface or from an overlying water-bearing formation.
8. Drilling of neighboring wells.
9. Poor management, such as improper casing, unwise rate and time of pumping, and failure to clean.

"The Condensation of Gasoline from Natural Gas," Chapter XI, is much too short for such an important subject as natural gas condensate. It can well be expanded in a future edition considerably. This is in part overcome by the rather full bibliography given.

The chapters on "Refinery Technology" and "Refinery Engineering" bristle with detailed information as to plant equipment and methods of operation. Full prints of actual refineries built upon actual specifications are given in these chapters. The subheads of these three chapters, indicate their scope and breadth.

The Refining of Petroleum.

The Dry- or "Cracking"-Distillation of Paraffin-Base Petroleum.

The Dry- or "Cracking"-Distillation of Mid-Continent Petroleum.

The Fractional-Distillation of Petroleum with the Aid of Steam.

The Operations in Some Pennsylvania Refineries.

The Manufacture of Paraffin Wax.

Petroleum Products Manufactured in the Appalachian Field.

The Operations in the Refining of Asphalt-Base Petroleum.

Petroleum Products Manufactured in the Mid-Continent Field.

The Value of Oklahoma Petroleum.

The Products of California Petroleum.

California Oil Refineries and Topping Plants.

The Distribution of Petroleum Products to the Trade.

Systematic Methods of Testing Petroleum Products.

The Processes of "Sunning" and "Reducing."

The Dehydration of Petroleum.

The Continuous Distillation of Petroleum.

The "Cracking" Process.

The Chemical Treatment of Petroleum Distillates.

The Desulphurization of Mineral Oils.
 The Decolorization of Petroleum Distillates.
 The Production of Asphalt by the Oxidation of Petroleum.
 Petrolatum.
 General Specifications.
 Reservoirs.
 Tanks.
 Stills.
 Condensers.
 Agitators.
 Paraffin Wax Plant Equipment.
 Miscellaneous Refinery Equipment.
 Fire Extinction.

A special chapter on "Hygienic Considerations" in refineries gives welcome information. The prophylactic measures necessary for the well being of refinery workers are stated in clear-cut language.

"Some Problems of the Petroleum Industry" indicates quite clearly some of the urgent points in petroleum work crying for solution. No reader of the work can fail to find hundreds of problems calling for urgent clarification. This solution would require scientific work of the highest integrity, which could readily be carried on in our institutions of learning, and which would not be simple Uhlan work, but would call for the highest skill and capabilities of any physical, organic, or inorganic chemist in our universities. It may be that some of our institutions of learning will install specific courses in hydrocarbon chemistry, much as some have developed courses on ceramics, tanning, etc., which call for high scientific work.

The shale-oil industry is taken up at some considerable length, mainly from the Scottish point of view, as most of the work along this line has been done in Scotland and plants are in actual operation there on large-scale production. For America this subject is of great significance from the viewpoint of the rapid depletion of natural oil wells. For the day is not far distant when large shale-oil plants will be installed to recover the ammonia content for fertilizing and war purposes, and the oil content for the various purposes for which petroleum is used.

A glossary of bituminology closes the book. The glossary is quite complete and it is of value in clarifying the various terms which are used in different parts of the industry.

This work by Bacon and Hamor is a scholarly contribution to the petroleum industry of America. It covers in an "up-to-date" manner the subject in full. A tremendous amount of library and plant research has been carried on by the authors to bring together all available information upon the subject of the American petroleum industry. It will in all likelihood fulfill the ideal of the authors, stated in the preface, and will be used as a text-book in the classroom, and further as a reference book. Being ably written and authoritative, the treatise will fulfill a need and should be on the shelf of any worker in the petroleum oil field.

GUSTAV EGLOFF.

Handbook of Chemistry and Physics. Fifth Edition, 1916. 414 pages. Price \$2.00. Cleveland, Ohio: The Chemical Rubber Company.

This little handbook is designed to be a ready-reference pocket book of chemical and physical data. The material is compiled from the most authoritative sources such as the Chemiker Kalender, the Landolt-Börnstein-Meyerhoffer tables, and a large number of text-books and other reference works. The material is condensed and is well indexed.

The present fifth edition is a revision of the previous one under the direction of Charles B. Hodgman and M. F. Coolbaugh of the Case School of Applied Science. A new and more complete table of gravimetric factors is included and the following tables have been added: heats of formation of important compounds, an anion analysis scheme, flame and bead tests, natural logarithms, algebraic formulæ, elementary derivatives and integrals.

Personal

Mr. Enoch A. Barnard has joined the instructing staff of the Department of Mining and Metallurgy of the University of Wisconsin for the second semester ending in June. He is on a leave of absence from his position as assistant testing engineer at the Washoe smelter, Anaconda, Mont., and will return on the completion of his work at Madison, Wis.

Mr. Jay A. Carpenter has resigned as metallurgist for the West End Consolidated at Tonopah, to accept the position of superintendent of the Nevada Packard mines at Rochester.

Mr. Fred G. Farish has resigned as manager of the Lluvia de Oro Gold Mining Company to take up the management of the Mineral Hill Consolidated Copper Co., Tucson, Ariz.

Mr. C. A. Filteau has resigned as manager of the St. Lawrence Talc Co., Natural Springs, N. Y., to become manager of the National Mines, Ltd., Cobalt, Ontario.

Prof. Henry M. Howe has been awarded the John Fritz Medal for 1917 for his investigations in metallurgy, especially in the metallography of iron and steel.

Mr. Walter Laib has been appointed superintendent of The Ohio Salt Company at Rittman, Ohio. This plant has a daily salt capacity of 5000 barrels, in addition to its production of chlorate of potash, manufactured under Mr. Laib's patent.

Dr. Arthur D. Little addressed the Canadian Manufacturers' Association and the Royal Canadian Institute at Toronto, on Dec. 1 and 2 last, respectively. A long abstract of his addresses, which were both on the same subject, "Scientific and Industrial Research," was printed in National Progress, a Canadian monthly magazine, for January.

Dr. Morton G. Lloyd, formerly technical editor of the Electrical Review and Western Electrician, has accepted a temporary appointment as associate electrical engineer in the Bureau of Standards, Washington, D. C., where he will be occupied with the various public utility investigations in which the Bureau is engaged.

Mr. J. H. McCreery has been elected secretary and treasurer of the newly organized firm of Ophuls, Hill & McCreery, consulting engineers of 112 West Forty-second Street, New York. Mr. McCreery will specialize in mining and mechanical engineering. The firm will make a specialty of appraisals of industrial power plants, also ice and refrigerating plants.

Mr. Francis C. Ryan, superintendent of Midland Recoveries Co. of Hammond, Ind., has been appointed chief electro-metallurgist at the U. S. Bureau of Mines station at the University of Washington. He will conduct research work in the use of electricity in metal working in the university laboratories. Dr. Dorsey A. Lyon is chief of the recently organized Bureau of Mines station at Seattle.

CURRENT MARKET REPORTS

The Iron and Steel Market

The actual course of the steel market appears to have diverged very materially from the appraisal generally made of it. The German peace proposal of Dec. 12 was assigned as a potent factor in quieting the market, while the holidays and usual year-end adjustments could be counted upon as an influence, and finally the observation was vouchsafed that the German declaration of unrestricted submarine warfare, beginning Feb. 1, was another cause, or explanation, of the quiet market.

There has been ample explanation for an assumed fact, but the question raised in the past ten days is whether any such fact existed. It now appears that bookings by the mills have been quite heavy since the first of the year, and the testimony of market prices, so far as it is acceptable as evidence, is loud and emphatic. In the week ended March 10 the increase in the average price of finished steel products was by a large margin the greatest for any week in the history of this steel price movement, extending now over a period of more than two years. March 5 all the regular wire products, including wire, barb wire and nails, were advanced \$4 a ton, while iron and steel pipe, line pipe, O. D. pipe and oil country goods were also advanced \$4. On March 8 the Carnegie Steel Company advanced bars and shapes \$7 a ton and plates \$15 a ton, other mills immediately following. The new prices are: Plain wire, 2.15c.; wire nails, base, \$2.20; steel pipe, 60 per cent off list; bars, 3.35c.; shapes, 3.60c.; plates, 4.50c. If the various influences mentioned exerted a quieting influence on the steel market the statistical fact is that a carefully kept weighted average shows that from Jan. 1, 1915, when the market started advancing, to Dec. 12, 1916, the date of the German peace proposal, there was an average advance in finished steel products of \$1.73 per net ton per month, while in the three months Dec. 12 to March 12 there was an average advance of \$3.60 per month.

The mills are in a much more completely sold out condition than formerly. There had been a great deal of tonnage placed on books in the form of specific orders, calling for certain deliveries in the future, as the buyers, shippers, fabricating shops, car and locomotive shops, etc., would be able to fabricate the material. The tonnage obligations on books, as reported by the Steel Corporation, for instance, represented the equivalent of the tonnage that could be produced in a certain number of months, but the tonnages of different classes of materials were quite out of proportion, and the time for which the mills were solidly booked was much less than the average time. The mills were reserving certain tonnages for regular customers. Since the first of the year a great deal of this reserved tonnage has been converted into actual contracts, while distinct promises have been made in other instances, sometimes all details being arranged except the price, whereby the regular consumers are covered in nearly all instances to the close of the year and the mills are booked almost solidly for the period, with all prospects that deliveries will be so behindhand that the tonnage will run far into 1918. In other words, there can be very little additional buying except for 1918.

There is no information as to the volume of steel orders placed or about to be placed by the United States government in its war preparations but the evidence in the market is that the tonnage is crowding the mills. It is to be given every preference desired by the authorities and the prices are understood to have no relation to

those now prevailing, or recently prevailing, in the open market.

The traffic congestion on the railroads interfered greatly with production in February. Pig iron production was 10 to 15 per cent below what it should have been, even in February weather, on account of insufficient coke deliveries due chiefly to car shortages in the coke regions, and while steel production was not greatly curtailed by reason of pig iron shortage there was considerable curtailment on account of fuel shortage and inability to ship finished product. A slight improvement in traffic conditions seemed to be promised for March, but on March 4 the heaviest snowfall of the season gave conditions in the Central West a fresh backset, and real recovery is still for the future. While references are usually made to "car shortage" it is not a case of the number of cars but of their position. The variable in the equation determining car supply is the temperature, as affecting the steaming capacity of locomotives, and the hopes of the iron and steel trade must be for the weather to get warm.

PIG IRON

The pig iron markets have been endeavoring to equalize, but with indifferent success. Southern iron has advanced rather sharply and is now generally held at \$30, Birmingham, with a limited tonnage available at less. At this level it would not undersell northern iron except in spots. Valley foundry iron, however, seems to have become established at \$35, furnace, for second half delivery, with basic still quotable at \$30, and an equalization between these grades is needed. Throughout the pig iron market there is a strong advancing tendency.

UNFINISHED STEEL

For early deliveries billets and sheet bars would readily bring \$65, the scarcity being even more pronounced, but a new feature in the situation is a distinct indisposition of buyers to interest themselves in forward deliveries. Apparently a theory has been developed that on account of much more steel making than steel finishing capacity being in course of construction unfinished steel is likely to become more plentiful relative to finished products.

Non-Ferrous Metal Market

March 9.—Copper has remained practically unchanged, while tin has advanced in an uncertain market. The Trust price of lead has been advanced again. Spelter has remained firm in a quiet market. Silver has dropped slightly.

Copper.—The copper market for the past two weeks has been dull for the most part, with early deliveries hard to get. Exports in February were 24,937 tons. The Boston News Bureau places the February refinery output at 170,000,000 lb., against 180,000,000 lb. in January. The freight embargoes have curtailed production somewhat. Lake is now held at 36.00 cents with electrolytic at 37.00 cents. Second quarter electrolytic is held at 35.00 cents, third quarter at 32.50 and fourth quarter at 31.00 cents.

Tin.—Around the first of the month there was a fairly good business done in tin and the market advanced from 50.00 cents on Feb. 26 to 54.12½ on March 8, for spot Straits. American deliveries for February were below 4000 tons. On March 1, there were 1852 tons in store, and 1175 tons on dock, according to the American Metal Market. The sailing of steamers is very uncertain and the market is more or less nervous. Recently there has been some fair business in Banca, Australian and Chinese tin.

Lead.—On March 2 the Trust price of lead was advanced to the basis of 9.00 cents New York. Early deliveries remain scarce and the outside market stands from 10.00 to 11.00 cents.

Spelter.—The consuming demand for spelter has been very dull although the market remains firm and practically unchanged at 11.00 cents. There has been some buying by dealers but this has as yet not stimulated the market to any extent.

Other Metals.—Antimony has dropped from 33.00 cents on Feb. 26 to 30.50 cents on March 8, in a dull market. No. 1 Virgin aluminum is quoted at 58.00-60.00 cents. Magnesium is unchanged at \$3.00-\$3.50, cadmium is \$1.50, quicksilver \$108.00, platinum \$105.00, cobalt \$1.70, and silver has dropped from over 77 cents to 75½¢.

Chemical Market

Coal Tar Products.—There has been considerable activity noted in this division of the chemical industry during the fortnight and a number of interesting developments have occurred.

Benzol.—A very firm situation has prevailed throughout the past two weeks. Manufacturers are holding tight and while a few contracts have been made covering deliveries for the next three years these offerings have generally been withdrawn and producers are not now inclined to sell in large quantities for other than deliveries this year.

Toluol.—The situation in this product is even firmer than with benzol. Contracts have been placed at very high levels as compared with those prevailing some few months ago and manufacturers realizing that the situation favors their viewpoint are not inclined to let go of supplies for deliveries covering extended periods. The demand for intermediates from toluol has been quite heavy throughout the interval.

Aniline Oil.—It now seems that the recent advance in this product was due to the purchase of some 200 tons of the material by a large producer who is no longer selling the product but is consuming it in the production of a material that allows of a large margin of manufacturing profit. The situation remains tight and while the production is large prices hold very well indeed with spot offerings greatly restricted.

Diphenylamine.—As a result of quiet buying on the part of both American and Canadian explosive manufacturers, there has been considerable interest shown in this product and important business has been placed at the low price of about 80¢. For ordinary average business sellers generally quote 85¢.

Carbolic Acid.—In contrast to other firm markets, the *phenol* situation is weak. Manufacturers are quite frank in this statement that they are far from pleased with existing conditions. Some of the large producers admit that considerable stocks remain at plants and are difficult to move. Government buying would strengthen the market, but so far buying of this character has not been important.

Naphthalene.—A very firm situation has prevailed for this product throughout the two weeks. The usual spring demand has been heavier than usual and buyers have found difficulty in securing sizable lots of balls. Price has been higher and very strong.

Creosote Oils.—Scarcity of supplies and a heavy demand from consuming sources have created a firmer situation in this line than has prevailed for some time past.

New Developments.—Hardly a day passes without announcements of new developments in the intermediate

trade. During the past fortnight new productions of meta-nitraniline, meta-phenylenediamine, paranitraniline, malachite green, cinnamic acid, synthetic, and other products were announced.

Heavy Chemicals.—A heavy local business in heavy chemicals has passed since we last reported. This is due to an increased consuming demand and the fact that buyers have been forced into the market for their immediate needs owing to the failure of the railroads to deliver material ordered months ago.

Brimstone.—Producers advanced their price to the level of \$45, stating that this was due to the difficulty of securing transportation facilities. This situation, of course, reflects in the market for brimstone sulphuric acid which has strengthened to a marked degree with a large movement noted at Eastern points. Spot lots of acid have been remarkably low throughout the interval. Pyrites acid has, in sympathy, shown considerable firmness.

Nitrate of Soda.—The ocean-freight situation has created the highest market that has prevailed since the abnormal rise of a year ago. It is rumored that the government will in the event of hostilities take over the nitrate business. The firmness of the crude material finds reflection in the *nitric acid* situation which is from 25 per cent to 50 per cent higher than two weeks ago. *Bichromate of potash* has eased off under pressure of offers from a new producer. *Bichromate soda* has been quiet with prices low. There are now eight producers of this product. *Quicksilver* has been easier because of arrivals from the Coast and Mexico and the lack of consuming demand due to recent high prices. *Soda ash* has been in free movement. The railroad embargoes have forced some buyers into the open market. Nineteen hundred and eighteen business is improving. One of the large manufacturers has recently been in the market to cover requirements. *Caustic soda* is higher and there has been heavy buying because of non-delivery of contracts. For late 1917 and 1918 contracts have been higher. *Bleaching powder* in domestic drums has been freely offered. Contracts have been placed at low prices. Owing to export restrictions, export drums have been offered somewhat more freely. *Epsom salts'* manufacturers have advanced their prices and owing to the difficulty of getting supplies from the Orient, spot lots of the salt have been very light.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET MARCH 8, 1917

Acetone, Drums	lb.	23	—	.23½
Acetic, 28 per cent	lb.	103½	—	.04
Acetic, 56 per cent	lb.	.08	—	.09
Acetic, glacial, 99½ per cent carboys	lb.	.24	—	.25
Boric, crystals	lb.	1.04½	—	.12
Citric, crystals	lb.	.71	—	.72
Hydrochloric, commercial, 18 deg.	lb.	.01¾	—	.01½
Hydrochloric, 20 deg.	lb.	.01½	—	.01¾
Hydrochloric, C. P., conc., 22 deg.	lb.	.01¾	—	.02
Hydrofluoric, 30 per cent, in barrels	lb.	.04¾	—	.05
Lactic, 44 per cent	lb.	.13	—	.14
Lactic, 22 per cent	lb.	.04½	—	.04½
Nitric, 36 deg.	lb.	.05	—	.05½
Nitric, 42 deg.	lb.	.06½	—	.08
Oxalic, crystals	lb.	.45½	—	.46
Phosphoric, 85 per cent	lb.	.27	—	.29
Picric	lb.	.70	—	.75
Pyrogallol, resublimed	lb.	3.50	—	4.00
Sulphuric, 66 deg.	ton	17.00	—	20.00
Sulphuric, 66 deg.	ton	28.00	—	30.00
Sulphuric, oleum (Fuming), tank cars	ton	35.00	—	40.00
Tannic, U. S. P., bulk	lb.	.45	—	.50
Tartaric, crystals	lb.	1.10	—	.83
Oxalic, grain, 188 proof	gal.	2.75	—	4.6
Alcohol, Wood, 95 per cent	gal.	1.00	—	1.02
Alcohol, Denatured, 180 proof	gal.	.66	—	.67
Alum, ammonia lump	lb.	.04	—	.04½
Alum, chrome ammonium	lb.	1.8½	—	1.9½
Alum, chrome potassium	lb.	.30	—	.35
Alum, chrome sodium	lb.	.20	—	.22
Alum, potash lump	lb.	.05½	—	.05½
Aluminium Sulphate, technical	lb.	.02½	—	.03
Aluminium Sulphate, iron free	lb.	.03½	—	.03½
Ammonia aqua, 26 deg. carboys	lb.	.05½	—	.05¾
Ammonium carbonate	lb.	.10	—	.11
Ammonium nitrate	lb.	.14	—	.14½

Ammonium sulphate, domestic.....lb.	.047½	.45
Amyl acetate.....gal.	4.00	4.25
Arsenic, white.....lb.	11½	.12
Arsenic, red.....lb.	.25	.12
Barium chloride.....ton	90.00	95.00
Barium sulphate (Blanc Fixe), powder.....lb.	.04	.04½
Barium nitrate.....lb.	.11	11½
Barium peroxide, basis 70 per cent.....lb.	.27	.30
Bleaching powder, 35 per cent, chlorine, domestic, drums.....lb.	.031½	.03½
Borax, crystals, sacks.....lb.	.07	.07½
Brimstone, crude.....ton	45.00	
Bromine, technical.....lb.	1.00	1.35
Calcium, acetate, crude.....lb.	.03	.03½
Calcium, carbide.....ton	80.00	90.00
Calcium chloride, 70-15 per cent, fused, lump.....ton	26.00	30.00
Calcium peroxide.....ton	1.70	1.75
Calcium phosphate.....lb.	.30	.32
Calcium sulphate.....lb.	.01	.01½
Carbon bisulphide.....lb.	.04	.04½
Carbon tetrachloride, drums.....lb.	.16	.17
Caustic potash, 82-92 per cent.....lb.	.78	.80
Caustic soda, 75 per cent.....100 lb.	4.25	4.30
Chlorine, liquid.....lb.	.15	.16
Chlorine sulfate.....lb.	1.00	1.15
Copperas.....100 lb.	1.00	1.15
Copper carbonate.....lb.	.33	.35
Copper cyanide.....lb.	.70	
Copper sulphate, 99 per cent, crystals.....lb.	.09	.09½
Cream of tartar, crystals.....lb.	.43	.43½
Epsom salt, bags.....100 lb.	3.25	3.75
Formaldehyde, 40 per cent.....lb.	.12½	.13
Glauber's salt.....lb.	.65	.70
Glycerine, bulk, C. P.....lb.	.54	.55
Iodine, resublimed.....lb.	3.50	3.55
Iron oxide.....lb.	.02	.08
Lead acetate, white, crystals.....lb.	.14	.14½
Lead arsenate.....lb.	.10	.10½
Lead nitrate.....lb.	.16½	.17
Litharge, American.....lb.	.08½	.09½
Lithium carbonate.....lb.	1.05	1.06
Manganese dioxide.....lb.	.60	.65
Manganese sulphate.....lb.	.40	.45
Magnesium carbonate, U. S. P.....lb.	.24	.27
Nickel salt, single.....lb.	.14	.14½
Nickel salt, double.....lb.	.11	.11½
Phosphorus.....lb.	1.15	1.20
Phosphorus, yellow.....lb.	.85	.90
Potassium bichromate.....lb.	.36	.38
Potassium bromide, granular.....lb.	1.00	1.01
Potassium carbonate, calcined, 80-85 per cent.....lb.	.35	.45
Potassium chlorate, crystals.....lb.	.62	.63
Potassium cyanide, 98-99 per cent.....lb.	1.90	2.00
Potassium iodide.....lb.	2.90	2.92
Potassium muriate, 80-85 per cent basis of 80 per cent.....ton	415.00	425.00
Potassium nitrate.....lb.	.30	.32
Potassium permanganate.....lb.	.90	3.60
Potassium prussiate, red.....lb.	2.50	2.75
Potassium prussiate, yellow.....lb.	.90	.91
Potassium sulphate, 90-95 per cent basis 90 per cent.....ton	325.00	350.00
Rochelle Salts.....lb.	.36½	.37
Sal ammoniac, gray gran.....lb.	.10	.12
Sal ammoniac, white gran.....lb.	.18	.19
Sal soda.....lb.	1.10	1.20
Salt cake.....lb.	2.00	1.05
Silver cyanide.....oz.	.70	...
Silver nitrate.....oz.	.47½	...
Soda ash, 58 per cent, light, flat.....lb.	.03	.03½
Soda ash, 58 per cent, dense, flat.....lb.	.05	.05½
Sodium acetate.....lb.	.09	.10
Sodium benzoate.....lb.	7.00	7.50
Sodium bicarbonate, domestic.....100 lb.	1.85	1.95
Sodium bicarbonate, English.....lb.	.16	.16½
Sodium bichromate.....lb.	.16	.16½
Sodium bisulphite, powd.....lb.	.04½	.05
Sodium chlorate.....lb.	.25	.27
Sodium cyanide.....100 lb.	1.30	1.30½
Sodium fluoride, commercial.....lb.	.11½	.12½
Sodium hyposulphite.....lb.	.01½	.02
Sodium nitrate, refined.....lb.	.05½	.05¾
Sodium nitrite.....lb.	.11	.12
Sodium peroxide.....lb.	1.00	1.15
Sodium phosphate (tri).....lb.	.04½	.04¾
Sodium prussiate, yellow.....lb.	.31	.32
Sodium silicate, liquid.....100 lb.	1.25	1.30
Sodium sulphide, 30 per cent, crystals.....lb.	.03	.03½
Sodium sulphide, 60 per cent, fused.....lb.	.02½	.03
Sodium sulphite.....lb.	.03½	.03¾
Sodium sulphate.....lb.	.23	.28
Sulphur chloride, drums.....lb.	.29½	...
Sulphur dioxide, liquid, in cylinders.....100 lb.	2.55	2.60
Sulphur, flowers, sublimed.....100 lb.	1.15	2.20
Sulphur, roll.....lb.	45.00	46.00
Sulphur, crude.....lb.	1.15	1.20
Tin bichloride, 50 deg.....lb.	.13½	.13¾
Tin oxide.....lb.	.54	.54½
Zinc carbonate.....lb.	.24	.26
Zinc chloride.....lb.	.15	.15½
Zinc cyanide.....lb.	.50	...
Zinc dust.....lb.	.20	.21
Zinc oxide, American process XX.....lb.	1.14½	.12
Zinc sulphate.....lb.	.06½	.07

Coal Tar Products (Crude)

Benzol, pure, water white.....gal.	.57	.58
Benzol, 90 per cent.....gal.	.53	.54
Toluol, pure, water white.....gal.	1.80	1.90
Xylol, pure, water white.....gal.	.60	1.00
Solvent naphtha, water white.....gal.	.23	.24
Solvent naphtha, crude heavy.....lb.	.16	.18
Creosote oil, 25 per cent.....gal.	.26	.29
Creosote oil, 20 per cent.....gal.	.26	.25
Pitch, various grades.....800 lb.	20.00	20.00
Carbolic acid, crude, 95-97 per cent.....lb.	.95	1.00
Carbolic acid, crude, 50 per cent.....lb.	.55	.60
Carbolic acid, crude, 25 per cent.....lb.	.28	.30
Creosol, U. S. P.....lb.	.19	.20

Intermediates, Etc.

Alpha naphthylamine.....lb.	1.00	1.25
Aniline oil.....lb.	.27½	.29
Aniline, solid.....lb.	.28	.31
Anthracene, 80 per cent.....lb.	1.0	1.0
Benzaldehyde.....lb.	4.00	4.50
Benzidine, base.....lb.	1.65	1.80
Benzoin acid.....lb.	7.75	8.50
Beta Naphthol, sublimed.....lb.	1.80	.85
Dichlor benzol.....lb.	.48	.50
Dimethylaniline.....lb.	.56	.60
Diphenylamine.....lb.	.85	.90
H-Acid.....lb.	Nominal	
Metaphenylenediamine.....lb.	1.25	1.50
Monochlorbenzol.....lb.	.34	.35
Naphthalene, flake.....lb.	.09½	.09¾
Naphthionic acid, base.....lb.	1.15	2.00
Nitro naphthalin.....lb.	.45	.50
Ortho-toluidine.....lb.	1.20	1.25
Para-aminophenol.....lb.	4.25	4.50
Paranitraniline.....lb.	1.00	1.00
Paraphenylenediamine.....lb.	3.50	3.75
Para toluidine.....lb.	1.75	2.00
Phenol, U. S. P.....lb.	42½	.45
Resorcin, technical.....lb.	9.00	
Resorcin, pure.....lb.	17.00	18.00
Salicylic acid.....lb.	.75	.80
Salol.....lb.	1.35	1.50
Sulphanilic acid.....lb.	3.00	
Tolidin.....lb.	3.00	
Toluidine-mixture.....lb.	.90	1.00

Petroleum Oils

Crude (at the Wells)

Pennsylvania.....bbl.	3.05	...
Corning, Ohio.....bbl.	2.85	...
Somerset, Ky.....bbl.	2.18	...
Wooster, Ohio.....bbl.	2.05	...
Indiana.....bbl.	1.73	...
Illinois.....bbl.	1.70	...
Oklahoma and Kansas.....bbl.	1.70	...
Caddo, La., light.....bbl.	1.70	...
Coriscanna, Tex., light.....bbl.	1.70	...
California.....bbl.	.73	.82

Lubricants

Black, reduced, 29 gravity, 25-30 cold test.....gal.	.13½	.14
Cylinder, light.....gal.	.21	.26
Cylinder, dark.....gal.	.18	.19
Extra cold test.....gal.	.20	.31
Paraffine, high viscosity.....gal.	.20½	.22
Paraffine, 903 sp. gr.....gal.	.21½	.22
Paraffine, .865 sp. gr.....gal.	.18½	.19

Flotation Oils

Pine oil, steam distilled.....gal.	.59	...
Pine oil, destructively distilled.....gal.	.47	...
Pine-tar oil.....gal.	.19	...
Pine-tar oil, double refined.....gal.	.30	...
Pine oil, light.....gal.	.37	...
Pine oil, heavy.....gal.	.26	...
Pine tar, thin.....gal.	.13	...
Turpentine, crude.....gal.	.38	...
Hardwood oil, f.o.b. Michigan.....gal.	.16	...
Creosote, coal tar, neutral.....gal.	.15	...
Creosote, coal tar, acid.....gal.	.21	...

Vegetable and Other Oils

China wood oil.....gal.	.13½	.15
Cottonseed oil, crude.....gal.	.86	...
Linseed oil, raw, cars.....gal.	.93	...
Peanut oil, crude.....gal.	1.00	...
Rosin, 280 lb.....bbl.	6.00	...
Rosin oil, first run.....gal.	.38	...
Rosin oil, fourth run.....gal.	.70	...
Soya bean oil, Manchuria.....gal.	.13	...
Turpentine, spirits.....gal.	.51	...

Miscellaneous Materials

Barytes, floated, white, foreign.....ton	38.00	40.00
Barytes, floated, white, domestic.....ton	25.00	35.00
Beeswax, white pure.....lb.	.52	...
Carbauba wax, highest grade.....lb.	.51	...
Chalk, light, precipitated, English.....lb.	.61	...
Feldspar.....ton	8.00	12.00
Fuller's earth, powdered.....100 lb.	8.00	1.05
Red lead, dry, carloads.....lb.	10½	...
Soapstone.....ton	10.00	12½
Talc, American, white.....ton	10.00	13.00
White lead, dry.....lb.	.09½	...

Refractories, Etc.

(F.O.B. Works)

Chrome brick.....net ton	120.00	130.00
Chrome cement, Grecian.....net ton	80.00	90.00
Clay brick, 1st quality fireclay.....per 1000	40.00	50.00
Magnesia, Grecian, dead burned.....net ton	85.00	90.00
Magnesia brick, Grecian, 9x4½x2½.....net ton	135.00	140.00
Silica brick.....per 1000	40.00	45.00

Ferrolloys

Ferro-carbon-titanium, carloads.....lb.	.12½	...
Ferrocromium.....lb.	Nominal	...
Ferromanganese, domestic, delivered.....ton	250.00	300.00
Ferromanganese, English.....ton	185.00	...
Ferromolybdenum, per lb. of Mo.....lb.	4.00	...
Ferrosilicon, 50 per cent carloads del. Pitts- burgh.....ton	200.00	250.00
Ferrosilicon, 50 per cent, contract.....ton	100.00	...
Ferrotungsten, 75-85 per cent, f.o.b. Pitts- burgh.....lb.	1.95	...
Ferrovandium, f.o.b. works.....lb.	2.75	3.00

INDUSTRIAL

Financial, Construction and Manufacturers' News

Financial

The Agricultural Development Company, incorporated under the laws of Maine, plans to manufacture a fertilizer that will contain almost 2 per cent of potash. This is to be done by utilizing the vast deposits of mused beds on the Maine coast.

Alcohol Products Co., Newark, N. J., has been incorporated with a capital of \$650,000 to manufacture and deal in anhydrous and aqua-ammonia and chemicals. The incorporators are H. T. Edgar, H. M. Miner, Brooklyn; H. W. Haines, Milburn, Alaska Sulphur Co., Minneapolis, Minn., has been incorporated with a capital of \$500,000.

Alaska Yukon Copper Co., Inc., New York, has been incorporated with a capital of \$100,000. The incorporators are K. Wein, A. Moessner and Clemens Ruttinger of Brooklyn.

Elenco Chemical Co., Mayfield, La., has been incorporated with a capital of \$5,000. The incorporators are J. Johnston, E. L. Johnson and J. J. Radford.

Booth Chemical Co., Jersey City, N. J., has been incorporated with a capital of \$100,000. The incorporators are J. M. Booth, Plainfield; W. H. P. Fisher, Jersey City; Arthur J. Donniez, Brooklyn.

Bronzo Alumina Corp., Tonawanda, N. Y., has been incorporated with a capital of \$16,000 to deal in aluminum, silicon, bronze, iron castings. The incorporators are F. A. Redner, J. E. Kaufman, J. H. Willing, 141 Masten Street, Buffalo, N. Y. Buffalo Chemical and Oil Co., Buffalo, N. Y., has been incorporated with a capital of \$5,000 to deal in chemicals and dyestuffs. The incorporators are N. P. Hoff, F. B. Steele, 182 S. Jones Place, Buffalo.

The Burnwell Mining Company, Dayton, Ohio, has been incorporated with a capital of \$100,000. The incorporators are Charles Dunn and S. B. Chilton.

California Aniline and Chemical Co., San Francisco, Cal., has been incorporated with a capital of \$50,000 to manufacture aniline dyes and chemicals. The incorporators are E. L. Hueter, H. P. Roach, L. H. Lewars, B. R. Bowron, E. C. Hueter.

Central Market Paper Co., Columbus, Ohio, has been incorporated with a capital of \$50,000. The incorporators are S. Ornstein, L. L. Goldberg, W. Painter, A. H. Journey, E. F. Schanfarber.

The Central Wooding Company, Portland, Me., has certified an increase in its capital stock from \$32,000 to \$88,000.

Centric Metal Co., Inc., New York, has been incorporated with a capital of \$25,000 to buy and sell minerals and by-products. The incorporators are L. Heppenheimer, J. and M. Krulan, 1102 President St., Brooklyn.

The Conney Extracting Company of Atlantic City, N. J., has been chartered with \$100,000 to extract cotton from mixed cottons and woolsens and manufacture chemicals and titles by Charles P. Tilton, Charles H. Parsons and Sadie A. Burris, all of Atlantic City, N. J.

The De Vere Chemical Co., 186 North 21st Street, Columbus, Ohio, has been incorporated with a capital of \$50,000 to manufacture chemicals. The incorporators are P. R. De Vere, P. E. Wilkinson, C. F. Williams, W. C. Shacklett and J. E. Waddy.

Empire Refineries, Inc., Augusta, Me., has been incorporated with a capital of \$5,000,000 to deal in gas, oil and other mineral bearing.

Empire State Zinc & Copper Co., Dover, Del., has been incorporated with a capital of \$1,000,000 to mine copper, gold, silver, etc. M. M. Brown, J. B. Bailey, Dover, Del., incorporators.

Esperanza Mining Co., New York, has been incorporated with a capital of \$2,000,000 to manufacture general mining and refining business. The incorporators are A. W. Britter, S. B. Howard, L. H. Gunther, all of New York.

The capital stock of the Francis Chemical Company of Providence, R. I., has been increased from \$40,000 to \$100,000, according to an amendment made to the articles of association of the State charter. The company, owned by Gabriel S. Schall, Inc., Manhattan, has been incorporated with a capital of \$100,000 to conduct a chemical business. The incorporators are H. Schall, L. Gabriel, S. H. P. Schall, 205 Pearl Street, New York City.

Garrett Foundry, Inc., New York, has been incorporated with a capital of \$35,500 to deal in iron, steel, manganese, foundries, machines. The incorporators are C. H. Fowler, A. W. Trotter, J. C. Garrett, 43 McDonald Street, Brooklyn.

The Gas Products Co., Muskegoe, Tex., has been incorporated with a capital of \$5,000. The incorporators are R. R. Owen, Muskegoe; H. Goschach, Muskegoe; E. Roschach Muskegoe.

Gasoline Producing Corp., Wilmington, Del., has been incorporated with a capital of \$1,000,000 to deal with a process of compressing gasoline oils from casing and head gas.

Gas and Coke Oven Corp., New York, has been incorporated with a capital of \$105,000 to deal in coke oven, stamp mills, smelting machinery, mine coal, oil, gas, construction. The incorporators are M. McEnany, L. M. Woodworth, G. H. Rowe, Jr., 122 Milton Street, Brooklyn.

The General Roofing Manufacturing Company announces the company has purchased the Mound City Paint & Color Co. and the Grege Wash Co., both of St. Louis, and the Leeper Paper Co. mill at Niagara Falls, N. Y., and that a new corporation has been organized, to be known as the Certain-teed Products Corporation.

In the new company's formation there will be issued \$3,500,000 first preferred 7 per cent cumulative stock, \$1,925,000 second preferred 7 per cent cumulative convertible stock and 60,000 shares of common stock. Headquarters will remain in St. Louis. The increased capital available under the new organization will be used in extending the business of the roofing company. The large mills in East St. Louis and Marseilles, Ill., York, Pa., and Richmond, Cal., will be enlarged and improved. The paper mill at Niagara Falls also will be enlarged and a roofing factory will be built adjoining it. The company will enter in an aggressive manner the paint and varnish field on a big scale, and it was because of this plan that the Mound City and Grege companies were taken over.

Glass Glass Co., Milbrook, N. Y., has been incorporated with a capital of \$300,000 to manufacture glass, glassware, electric light goods, molds, stools. The incorporators are J. F. Fitzharris, E. C. Wilson, F. D. Gill, East York and Thompson Streets, Philadelphia, Pa.

Great Lakes Chemical Co., Cleveland, Ohio, has been incorporated with a capital of \$25,000. The incorporators are Esther L. Jay, A. Akers, Edith L. Akers and H. S. Jay.

Charles A. Henderson Chemical Co., Inc., Anderson, Ind., has been incorporated with a capital of \$10,000 to deal in chemicals, patent medicines and stock food remedies. The incorporators are W. D. Kimball, H. R. Hayes and N. M. McCullough.

K. F. G. Products Co., New York, has been incorporated with a capital of \$10,000 to deal in chemicals, dyestuffs, ores, compounds, paints, drugs. The incorporators are S. Greenberg, I. Lowenbraun, B. L. Karlner, 116 Nassau Street.

Keokuk Glass Manufacturing Company, Keokuk, Iowa, has increased from \$250,000 to \$500,000. Samuel C. Kerr, president; A. T. W. Kerr, secretary.

Mansfield Paint Co., Mansfield, Pa., has been incorporated with a capital of \$150,000 to manufacture all kinds of paints, stains, etc. The incorporators are C. H. Ranck, Mansfield, Pa.; D. D. Buck, George W. Dillingham, all of Wilmington, Del.

The Mineral Paint Zinc Corporation of Newark, N. J., has increased its capital from \$400,000 to \$5,000,000. August Roche, Jr., is the agent.

The Montana Bingham Consolidated Mining Company voted for the increase of the capital stock to \$2,000,000. It is an increase from 1,500,000 shares of \$1 par value to 2,000,000 shares of \$1 par value, or \$3,000,000 capitalization. It is stated that the entire increase of 1,500,000 shares will go into the treasury for the purpose of making the proposition. The fund to be raised will be devoted to the development of the big Bingham domain on large lines. The company owns 170 acres of mineral property. It has a fifth interest in the adjoining Bingham Amalgamated, which embraces 300 acres. It is reported that a fund of \$200,000 cash has been guaranteed for a block of the treasury stock, and that prob-

ably ultimately a mill will be built at Bugaboo for the reduction of the second-class ores. The company has one development tunnel 4/85 feet in length and other workings.

The National Aniline & Chemical Company of New York City has filed application to establish offices in Charlotte, N. C. National Envelope Co., Kittery, Me., has been incorporated with a capital of \$300,000 to manufacture all sorts of paper goods, general printing, publishing.

National Potash Corp., Rochester, N. Y., has been incorporated with a capital of \$25,000 to manufacture potash, chemicals, soaps, etc. The incorporators are J. M. Dons, W. A. Delongue, T. J. Morrison, Rochester.

Pacific Steel & Copper Plate Co., San Francisco, Cal., has been incorporated with a capital of \$25,000 to deal in iron, copper, zinc and similar materials. The incorporators are G. R. Reed, C. M. Reed, A. A. Tappan, V. J. De Mammel, E. Reed, Jr.

Pan-American Leather Co., Middletown, has been incorporated with a capital of \$15,000 to manufacture leather and hides.

Pendennis Metals Corp., New York, has been incorporated with a capital of \$10,000 to do mining, milling, smelting. The incorporators are P. W. McQuillen, W. G. Wiechmann, E. H. Green, 49 Wall Street, Brooklyn. The incorporators are J. M. Dons, Del., has been incorporated with a capital of \$50,000 to manufacture and produce petroleum, etc. Incorporators are M. L. Brown, L. H. Irwin, H. W. Davis, all of Wilmington, Del.

Philadelphia Metal Drying Form Co., Philadelphia, Pa., has been incorporated to manufacture metal drying forms. The incorporators are H. E. Laffer, N. P. Coffin, Wilmington, Del.; C. M. Egner, Elkton, Md.

Pittsburg-Utah Potash Fertilizer Co., Wilmington, Del., has been incorporated with a capital of \$500,000 to carry on the business of chemists and chemical manufacturing. The incorporators are F. D. Bock, George W. W. L. Harty, local Wilmington incorporators.

The Quaker Valley Refining Co., Pittsburg, Pa., has been incorporated with a capital of \$100,000. The incorporators are H. J. Hackel, Pittsburg; A. E. Nesbit, F. R. Nesbit, both of Coraopolis, Pa.

The Regent Brass Foundry Co., Marysville, Ohio, has been incorporated with a capital of \$30,000. The incorporators are J. Klein, A. V. Birnbaum, A. J. Hale, S. M. Davis and E. Weinberger.

The Rio Hatch Mining Co., Ogden, Utah, has been incorporated with a capital of \$1,000,000. The incorporators are F. G. Taylor, L. R. Eccles, J. M. Eccles, J. B. Devine, W. H. Petty, J. Snowcroft of Ogden, Greenwood and C. D. Day of Salt Lake.

Silver Queen Mining Co., Erie, Pa., has been incorporated with a capital of \$100,000. The incorporators are H. P. Garrow, W. Bogart and Ida M. Darwin, all of Erie, Pa., are the incorporators.

The South Penn Oil Co. stockholders have voted to increase the capital from \$12,500,000 to \$20,000,000. The new stock to be issued as a 60 per cent stock dividend to holders of record.

Southern Chemical Co., Wilmington, Del., has been incorporated with a capital of \$150,000 to manufacture, buy, sell and deal in and with gas carbon, etc. The incorporators are H. E. Laffer, N. P. Coffin, H. T. Farrow, all of Wilmington.

Square Deal Foundry Corp., Greenwich, Conn., has been incorporated with a capital of \$5,000. The incorporators are H. J. Carr, H. Carr, Jr., K. Carr, all of Greenwich.

Standard Oil Co., Louisville, increases capital from \$3,000,000 to \$6,000,000. The Standard Oil Co., Milwaukee, Wis., has been incorporated with a capital of \$50,000 to manufacture farm equipments. The incorporators are E. J. DeGunter, David V. Jennings, Jos. P. Kalt, Jr., and E. J. Caster.

Sweetser & Bainbridge, Inc., Albany County, has been incorporated with a capital of \$1,000,000 to manufacture and deal in copper sulphate, by-product of copper steel, iron. The incorporators are E. F. Bainbridge, H. G. Batcheller, S. P. Sweetser, Slingerland.

H. D. Thatcher & Co., Potsdam, N. Y., has been incorporated with a capital of \$50,000 to deal in paper, lumber and wood products and novelties and manufacturing taking powder. The incorporators are R. H. Byrns, F. L. Dewey, I. H. Kendall, Potsdam.

Transatlantic Paper Co., Inc., New York, has been incorporated with a capital of \$25,000. The incorporators are J. C. Macre, H. Pressprich, 256 79th St., Brooklyn.

United Wool Stock Co., Inc., Manhattan, has been incorporated with a capital of \$25,000 to deal in clothes, paper, metals, etc. The incorporators are D. Savetsky,

1255 Franklin Ave.; M. Sheftman, 1325 Franklin Ave.; J. Neumark, 1330 Franklin Avenue, Bronx.

Vermont Paper Co., Portland, Me., has been incorporated with a capital of \$200,000, to do general quarrying, mining, milling, preparing for market, etc., all kinds of metals, ores, etc.

The Wadsworth Foundry Co., Wadsworth, Ohio, has been incorporated with a capital of \$15,000. The incorporators are W. F. Ries, W. A. Helmick, C. C. Patterson, T. J. O'Brien, Joseph Burgess and others.

Walker Foundry & Machine Co., Pittsburgh, Pa., has been incorporated with a capital of \$100,000 to manufacture machinery of all kinds.

Washington Pulp & Paper Corp., Richmond, Va., has been incorporated with a capital of \$4,000,000. The incorporators are A. J. Hennings, Maywood, Ill.; B. Thomas, Wilmette, Ill.

The Wheeling Steel & Iron Co. of Wheeling, W. Va., at its recent annual meeting, voted to increase the capital stock from \$7,500,000 to \$10,000,000. This increase of capital stock is made necessary because of the recent declaration of 50 per cent stock dividend by the company. By a unanimous vote of the stockholders also re-elected the old board of directors and adopted a resolution making the annual meeting date the fourth instead of second Tuesday in February. The old directors re-elected are: Isaac M. Scott, C. R. Hubbert, John Duncan, J. J. Holloway, B. W. Peterson, H. H. Hornbrook, W. A. Iselt, E. C. Ewing, William F. Stifel, Edward Hazlett and E. W. Ogelsby. The annual report showed that the company had a splendid year, with plants running at near capacity as conditions would permit, despite the fact that none of the company's products were used in the manufacture of munitions.

Construction and Operation

California

LOS ANGELES.—The Union Oil Company of California has purchased 3,000,000 barrels of oil from the E. I. Doheny properties in Mexico, and will withdraw six of its big tankers from California-Chilean service for the purpose of transporting the Mexican product through the Panama Canal and thence to Chile.

RIVERSIDE.—The Riverside Portland Cement Company will have a new plant in operation March 1. The company has installed electrical precipitation for removing the dust. This will be treated for its perch contents in a separate plant by a process worked out by the company chemists.

Colorado

DENVER.—The Barrett Company has contracted for the production of the by-product coke department of the Colorado Fuel and Iron Company. The Colorado Fuel and Iron Company has closed a contract with the H. Koppers Co. for the construction of a benzol plant to be used in connection with its coke ovens.

Delaware

WILMINGTON.—The Pusey-Jones Company has taken out permits for two new buildings to cost about \$100,000. The company manufactures paper-making machinery.

District of Columbia

WASHINGTON.—The Wayland Oil Company announced in its recent annual report that the company proposes to install a plant to extract gasoline from the natural gas which it produces. The new plant which will soon be ready for operation will add materially to the company's income.

WASHINGTON.—The Bureau of Mines contemplates the erection of a shale retort of the Del Monte type in the Navy Yard, Washington, D. C., to study the production of oil from shale. If the results justify further investigation the Bureau of Mines will probably erect a large retort with a capacity of possibly 500 gallons at either the station at San Francisco or Pittsburgh.

Illinois

CHICAGO.—H. Kramer Co. will erect a smelting plant on West 21st Place to cost \$50,000.

PEORIA.—The Globe Manufacturing Company will locate a paint factory here to meet the increasing demand for its products. The company manufactures paints, enamel, varnishes, stains, etc., and has had a small plant in East Peoria.

Indiana

MUNCIE.—The Owens Glass Company, of Toledo, Ohio, has purchased the plant of the Greenfield Bottle Works. Additions will be made and new machines installed for manufacturing bottles.

Iowa

CLINTON.—The Klein Paper Company of Clinton will construct a new paper mill with a capacity three times that of the present plant.

DAVENPORT.—A formal application for the location of the government nitrate plant on the Mississippi River near Rock Island arsenal has been sent to Washington by the mayors of Davenport, Rock Island, Moline, Bettendorf, East Moline and Silvis, and also 300 members of a committee in charge. A report of H. S. Putnam of New York City, consulting engineer, also accompanied the application.

DES MOINES.—The Carpenter Paper Company will erect a plant at 7th and Vine Streets, to cost \$50,000.

Louisiana

PLAQUEMINE.—The Southern Oil Refining Company will erect a \$50,000 plant five miles from this place. The present capacity will be 500 barrels a day of petroleum products.

Massachusetts

TURNERS FALLS.—The lower plant of the International Paper Company, formerly known as the Turners Falls Paper Company has been purchased by the Keith Paper Co., of Greenfield, Mass.

WEST WAREHAM.—A new rolling mill will be installed at the steel plant here. A new furnace is at present being built.

Michigan

WINDSOR.—A site of one and a half acres in the Windsor factory district has been purchased by Samuel Harris, of Galt, Ont., and Max Goldman, of Chicago, who intend to erect a brass-melting foundry.

Missouri

ST. LOUIS.—The Roxana Petroleum Company of Tulsa, Okla., has planned for the erection of a \$10,000,000 oil refinery in the East Carondelet district. The Roxana Company is a branch of the Dutch-Shell Corporation, which has extensive plants also in South America.

Nebraska

ALLIANCE.—The American Potash Company will erect a large addition to its present plant and install considerable new machinery. Activity in the potash industry in this field continues.

New York

BROOKLYN.—The W. Beckers Aniline and Chemical Works have let the contract for a new one-story brick factory to cost \$100,000.

Ohio

BARBERTON.—Mr. W. S. Galehouse of the Galehouse Realty Company is promoting a new chemical company to be incorporated for \$100,000. A plant will be erected as soon as a suitable site can be selected.

CLEVELAND.—The River Furnace Company has purchased an acre of ground on East 49th Street adjacent its plant for future plant development.

NILES.—The Grasselli Chemical Company, which is building a plant at Niles for the manufacture of sulphuric acid, has purchased six acres of land adjoining its present buildings for future developments.

WARREN.—The General Electric Company has purchased land and will erect an extension to its lamp factory to cost \$200,000.

WARREN.—The International Steel Tube & Rolling Mill will erect a new mill at once and later build its own rolling mill on a site of 25 acres in the Hamilton Tract west of the city.

WELLSBURG.—The McInnes foundry, which has been idle for two years, has been purchased by the Tri-State Foundry and Machine Company, of Pittsburgh, Pa. The plant will be enlarged and many improvements added.

Oklahoma

MUSKOGEE.—The Scandinavian Glass Co. will move its factory from Avant to Muskogee on account of the cheap gas offered by that city.

OKLAHOMA.—The Home Refining Company has ordered a large amount of machinery including tanks, stills and agitators,

and also 100 tank cars and will commence the erection of a refinery at once. The company recently purchased 85 acres in the Maplewood addition, east of the State Fair grounds. The company was organized last October and has a capital of \$250,000. The officers and directors are J. E. Jones, president; C. M. Joiner, vice-president; G. W. Dill, second vice-president; Secretary of State J. L. Lyon, treasurer; J. C. Willougham, secretary; and D. L. West, E. R. Kerby and A. T. Kellogg, directors.

TULSA.—The Alexander Kerr Glass Company will erect several new buildings at its plant in Sand Springs that will practically double the capacity of the plant.

Pennsylvania

CONNELLSVILLE.—The plant of the United States Electric Steel Company is expected to be completed about May 1. The erection of the furnace is expected to start within a few days.

SHARON.—Sharon men from Pittsburgh have obtained a lease on Rattlesnake Swamp in Cool Spring Township, Mercer County, and will erect a plant for converting the peat into fertilizer. Messrs. J. H. Connors and M. D. Hass, both of Pittsburgh, are interested in the proposition.

Rhode Island

LINCOLN.—The Lonsdale Bleachery and Dye Works will install a fuel oil system to take the place of coal in their power house.

Tennessee

KNOXVILLE.—The matter of a co-operative paper mill is being seriously considered by committees of the Knoxville Press Association and considerable research has been made by the committee in the preparation of data on the high cost of paper and the feasibility of some kind of co-operative establishment.

Texas

AUSTIN.—A company is being organized with a capital of \$200,000 for the purpose of manufacturing pulp, stumps, and stalks. It is understood that a demonstration plant will be established near Waco. It is understood that the finished products will be sold to powder makers for making smokeless powder for domestic consumption.

BEAUMONT.—The Texas Steel Company will put up a large plant here with a capacity of 300 tons per day. The limestone will be obtained from a point between San Antonio and Austin. The plant will cost \$300,000 and its output will be used in Texas and adjoining states. The company owns ore reserves in several counties in Northeast Texas, and a railroad from the ore field carries the raw material to Beaumont. Coke will be obtained from Alabama, West Virginia, and other states can be obtained by way of the Intercoastal Canal.

HOUSTON, TEX.—Cotton Seed Oil Co. of Texas has purchased site and will erect a mill near here to cost \$100,000, work to begin Mar. 1.

Utah

SALT LAKE CITY.—The National Dye & Chemical Company, a recently organized concern, will shortly commence manufacturing coal tar dyes. The company is at present negotiating for a site and for a coal property. The company expects to build a by-product plant. Mr. Ernest F. Bushman is the president and general manager of the company.

Washington

CONCRETE.—The Superior Portland Cement Company is changing the process in its plant from dry to wet. It is building 8 tanks of reinforced concrete, 26 feet high, and also a new substation. D. C. Fidelity is engineer in charge.

CONCRETE.—The Washington Portland Cement Company is installing a pulverized fuel plant of 100 tons capacity. W. O. Witherspoon is the engineer in charge.

LEAVENWORTH.—Large quantities of timber suitable for paper making are located in the vicinity of Leavenworth, within forty or fifty miles. An investigation of this section has been made by the Government Forestry Department and the facts have been disclosed that millions of feet of timber are present suitable for paper making on the various streams in the neighborhood. The timber is accessible so that it can be floated down the stream in the shape of cordwood. There is a vast amount of water power available and a local market for most of the output.

PORT ANGELES.—The Whalen Bros. Pulp Company will build one of the largest pulp mills in the west at this place. Work on the plant is expected to start in the near future.

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Contents for April 1, 1917

EDITORIAL:

Gas versus Waterpower.....	357
The Steel Corroding Report.....	357
Industrial Evolution.....	358
Barriers to Progress.....	359

READERS' VIEWS AND COMMENTS:

The United States in the Realm of Research. By Robert J. Anderson.....	360
The Application of Nitro-Aromatics in the Explosive Industry. By T. B. Munroe.....	360
The Electrochemical Industries and Hydroelectric Power on the Pacific Coast. By J. W. Beckman.....	360
Air Drying. By Carl Hering.....	360
More About the Rat Problem.....	360
Coming Meetings and Events.....	361
Nitro-Starch as an Explosive. By S. S. Sadtler.....	361
Industrial Activity Along a Southern Railroad.....	364
Properties of Metals and Alloys.....	365
Water Power Decision of U. S. Supreme Court.....	366
Metallurgy and Electrochemistry at the University of Cincinnati. By Ernest Edgar Thum and Albert Watson Davison.....	367
Is Not Gas Power Cheaper than Water Power? By H. G. H. Tarr.....	373
Notes and Experiments Pertaining to the Metallurgy of Zinc. By Edward Mackay Johnson.....	375
A Comparison System for Determining and Standardizing the Grain Size of Annealed Brass. By Geo. A. Miller, Jr.....	378
A Glossary of Terms Used in the Rubber Industry. By Frederic Danmerth.....	380
Electrolytic Equivalents of Gases. By Carl Hering.....	383
The Cementation of Iron and Steel. By Ernest Edgar Thum.....	385
Chemical Porcelain—Its Production and Quality. By Chas. F. Binns.....	395
SYNOPSIS OF RECENT METALLURGICAL AND CHEMICAL LITERATURE.....	399
RECENT METALLURGICAL AND CHEMICAL PATENTS.....	400
Explosions Due to Presence of Hydrogen in Electrolytic Oxygen Use of Rotary Kilns for Calcining Lime. By A. T. Wood.....	402
A New Rust-Proofing Material and Process.....	403
Stoneware Atomizing Nozzle for Acid Chambers.....	404
Detroit Meeting of American Electrochemical Society.....	405
New Engineering Society Organized in Southwest.....	405
Kansas City Meeting of American Chemical Society.....	405
PERSONAL.....	406
Current Market Reports—The Iron & Steel Market, Non-Ferrous Metal Market, Chemical Market and Chemical Price List.....	406
Industrial—Financial, Construction and Operation and Manufacturers' Notes.....	409

Gas versus Waterpower

If the keynote of modern industrial development is multiplication of individual human effort by power provided by nature, the mobilization of the industrial forces of a country comprises not only the men, but the natural power resources. The two principal ones are coal and waterpower. At the waterpower conference of the American Institute of Electrical Engineers and of the American Electrochemical Society a year ago in Washington it was brought out by the late H. G. Stott that in the present status of technical advance and with present conditions of financing power projects, steam is cheaper than waterpower up to a 60 per cent load factor. This statement emphasizes two facts. First, that waterpower is the power par excellence of all industries with very high load factor, such as the electrochemical and electrometallurgical industries. Second, the immense progress made in recent years by steam engineering is emphasized. Yet no finality has been reached in this direction as indicated by the very suggestive article by Capt. H. G. H. Tarr, published on page 373 of the present issue. His scheme is a novel one. It is to use the by-product gas producer, but to combine it not with the gas engine but with gas-fired steam boilers and steam turbines. It is noteworthy and deserves attention.

The Steel Corporation's Interesting Report

A year ago, in reviewing the United States Steel Corporation's report for the calendar year 1915, we referred to it as "the record of a wonderful year," not by any means wonderful as to the totals involved, but noteworthy as to the sweeping change that occurred, from operations at less than 50 per cent of capacity to operation at capacity, and more than rated capacity in the case of some departments.

The year 1916, for which the report has just been published, was a great year for tonnage and a wonderful one for profits. It was the first year since 1906 in which the steel industry operated at capacity for a full calendar twelvemonth. The corporation's output, in steel products for sale, was 15,460,792 tons, showing that despite the freight congestion toward the close of 1916 the corporation was able to reduce its stocks during the year by 81,296 tons.

The production in 1916 discloses quite closely the actual capacity, the average for the year or, generally speaking, the capacity on July 1, 1916. We have it that in the report for 1908 the capacity on April 1, 1901, the date the corporation began business, the capacity was 7,719,000 tons, and this checks with the fact that in 1902, operating at substantially capacity, and with additions to capacity, the actual production was 8,033,556 tons. To be more precise than accurate, in a period of

15 years and three months the capacity increased by 100.3 per cent. To be accurate and concise, the capacity doubled in 15 years. Of the increase, 19.5 per cent was due to the purchase of the Union, Sharon and Tennessee companies. The purchase of the Troy Steel Products Company did not add to capacity, as the plant was not bought to operate, nor was it operated.

Deducting from the total iron and steel exports of the United States the exports of scrap, pig iron, iron bars, cast-iron pipe and radiators, one has left what amounts substantially to the regular steel exports, comprising such items as the Steel Corporation reports as its steel exports. Apart from these it exports a little scrap and pig iron. The change effected by the buyer coming to the seller in these war times offering New York funds, not merely against vessel bill of lading but even against railroad bill of lading, is well illustrated by the comparison made below, of the country's exports and the Steel Corporation's exports:

	Corporation.	United States.
1912	2,233,570	2,531,131
1913	1,756,328	2,323,632
1914	1,096,234	1,387,296
1915	2,350,524	3,123,820
1916	2,466,793	5,131,261

In 1912 and 1913 the Steel Corporation's proportion of the total exports was 82.2 per cent, and the 17.8 per cent attributable to independent manufacturers was doubtless chiefly business done with Canada, hardly less difficult, so far as concerns the selling machinery, than strictly domestic business. In 1916 the Steel Corporation's proportion was only 48.1 per cent. When export business was difficult, and price concessions were common, the independents were quite content to allow their great and good friend to do the business. When the sales could be effected at the home office, for spot cash, and frequently at higher prices than ruled in the domestic market, the independents graciously accepted more than half the business going.

The Steel Corporation's profits in 1916 need not be considered at length, for 1916 represented merely a chance grouping of 12 consecutive months, in the last of which the profits per ton were more than double those in the first. The corporation's total earnings in the twelvemonth ended Dec. 31, 1916, after payment of interest on subsidiary company bonds, were \$333,574,178. If the fiscal year had ended three months earlier the earnings would have been about \$55,000,000 less, while if it ended three months later they would have been approximately as much more. The amount passed to book surplus was \$201,835,585, or one-fourth more than the total earnings in the best previous year, 1907. There were no appropriations for improvements, though there were expenditures of some \$65,000,000 for improvements chargeable to capital account, part of the funds being provided by previous appropriations and by transfers from depreciation accounts.

The maximum production of Bessemer steel ingots by the Steel Corporation occurred in 1906, with 8,972,655 tons. In 1916 the production was almost as large,

7,273,766 tons. Meanwhile the Bessemer departments at both the Homestead and Duquesne works had been abandoned entirely. The production of open-hearth ingots increased in the ten years from 5,438,494 tons to 13,636,823 tons.

Industrial Evolution

Within the knowledge of mankind there has never been a time when the civilized world has been making such wonderful strides toward man's humanity to man, as are brought to view every day in the handling of the labor problems in our large industries. For many years the inventive genius of the age has devoted itself to the perfection of machinery, and processes by which labor could be made more productive, always having in mind the elimination of the human hand; but time has demonstrated that no matter how perfect the mechanism, the human hand and mind are always needed; and it has gradually dawned upon the directing heads of our large corporations that, after all, their first great problem is the study of their workman, and the means necessary to make of him the one essential necessary to success—a thinking machine.

Darwin spent much time and thought upon the evolution of man from the monkey, but always failed to find the missing link, but to those of thoughtful mind there is no missing link when it comes to the study of the present-day labor conditions. In early times when the human race was unorganized and dependent on its individual efforts for food, it is very easy to see why might made right, and why to the victor went the spoils, and to a great extent that doctrine has survived to the present day. It has taken all the blood shed in Europe to bring to the minds of men in this country the idea that after all we are our brother's keeper, and that in just so much as we help our fellows so do we help ourselves. Thus we see the great spirit of co-operation taking its hold on the minds of people so that to-day we see men no longer work for a concern, but rather with it. What greater sign of the times can be seen than the sign in the New York subway, "We ask your help"? How would the directors of that corporation have felt about such a sign ten years ago?

Evolution, the great change, is necessarily coming slowly, but in this country particularly, with its great masses educated sufficiently to grasp the fundamentals of the human doctrine, "Thou shalt love thy neighbor as thyself," we will be nearing a social millennium. Lying, stealing, etc., are going out of fashion, selfishness brings quick retribution, and to-day the employer asks how he can give to those working with him so square a deal that the employee will feel it and be inclined to return good for good, just as in the past he has tried to return evil for evil.

If this country is to maintain its industrial supremacy it must be done by every man, woman and child doing their part to see that whatever task they have in hand must be done to the very limit of their ability, and our great corporations must set the example of careful training, fair remuneration and square dealing, and our in-

dustrial preparedness will be a success. No matter how much we may plan and train our people for some great cataclysm, it will come to nothing if we cannot make every individual see that they must do right for the sake of right, and the country whose people are firm believers in a religion which teaches them that to-day is the important day of their lives, and that they will be held accountable for mistakes right here on this earth, is the country which must surely dominate the world in the end.

Preparation for anything great or small is wise, and that preparation which teaches children so to live that their children may be greater than their parents are is the type of preparation which says that that people shall not perish from the earth. Nature works slowly, and it will take thousands of years and the bloodshed of many martyrs before the human race reaches a point where the lion shall lie down with the sheep; but we can each do something to see that our lives are so lived that we at least have helped to push along that mental evolution which is going on and has been going on ever since the cave man learned to make a fire with sticks.

Barriers to Progress

Despite all the efforts that have been made to bring about real democracy, despite all the dreams of a better social state and despite patents, the fact remains that useful inventions are about the hardest things there are to sell. The presence and increase of research laboratories have not aided in this respect.

A corporation is organized for the purpose of making money for its stockholders; it would not be organized if there were not a lively hope of this, and all the hue and cry against the desire of corporations to make profits is based upon defective psychology. This is so self-evident that we should hesitate to repeat it if it were not for the fact that we want to set it forth as a basis for what follows.

In the research laboratory of a manufacturing corporation the chemists, physicists and engineers address themselves to problems of saving expense, improving methods and bringing out new products, all with a view to eventual profit. To do this is sound and reasonable. It is also easy to understand that an invention that has its origin outside of the laboratory or works will not find the same welcome there that "a little thing of our own" does.

The outside invention coming from an unknown inventor is, so to speak, born poor. And the inventor may be a patent thief, which would make him fair game for anybody's boot. One never can tell; there are a great many of them at large. If a corporation is in dire need of an invention which originated outside of its aegis, there is a good chance for barter and sale. On the other hand, an invention of great economic value and sorely needed by society at large, may languish unused and unavailed of for years and years if the industry to which it pertains is not prodded into adopting it.

The public is the last to demand betterment. It does not know, is not scientifically informed, and nine times out of ten it regards waste as progress. It hates anything new, although it has faith that the last cry is perfection and 100 per cent yield. It only becomes incredulous at such times as when told that oleum is "more than 100 per cent sulphuric acid." The public does not know where savings may be made, and when it is not profitable to industry as it is organized to make a saving, the chances are that the waste will continue. Chemistry has not yet succeeded in teaching the public that waste is wrong; therefore, inventions that provide for no immediate profit to industry over the methods in vogue are almost impossible to sell. Another handicap lies in the fact that an invention is an invention; previous efforts to do this very thing have failed; the sum of human experience teaches us that it cannot be done; ergo, the inventor is an ass.

We published lately an article on the need of substituting nitro-aromatics for nitro-glycerin in commercial explosives. Without doubt many manufacturers would be willing to furnish nitro-aromatics and be glad to do so if the public would only take it; but the public still wants dynamite no matter what the cost. And now along comes nitro-starch, very much needed but doubtful if wanted by the public without educational pioneer work.

The inventor of a two-cycle explosion engine might rather solicit life insurance or try to sell Sermons of Cotton Mather than undertake to dispose of his patents. Everybody knows that the two-cycle engine is not worth looking into because it has always been a failure. And yet there is the idea, bound to come some day with nearly double the power for the same weight of machinery.

There is a method of tanning sole leather which makes it endure over twice as long as the best quality available to-day. It is not a very expensive process, but it is different and requires a new layout. Only a little of it is produced occasionally in a school of tanning and the product is bought up by a small leather dealer near by. He in turn sells it to neighboring cobblers who know leather but are not astute business men. They have spoiled their customers, who are not satisfied with ordinary sole leather any more. The rest of us cannot get that leather, and shoe manufacturers have shown no great desire to use it. Nevertheless, it would make shoes last longer, and we are, in effect, in the midst of a leather panic.

There doesn't seem to be any way to get desired inventions into use unless they are needed by manufacturers for immediate profits. At first thought the law of supply and demand seems to break down here, but we venture the opinion that this is not the case. The need for these inventions is present but the demand for them is not uttered. There is too little scientific public opinion abroad to assess their value. If we only had a more enlightened public opinion the real inventor would have a better chance. And his work would be of benefit to all of us.

Readers' Views and Comments

The United States in the Realm of Research

To the Editor of Metallurgical & Chemical Engineering

Sir:—The bibliography of alloys by Clarence Estes, published in the March 1, 1917, issue of *Metallurgical & Chemical Engineering*, should satisfy a long-felt want, not only by reason of its completeness but also because it brings the works of Desch and others up to date. This bibliography again brings rather forcibly to mind the relative position of this country in the realm of research. A rough calculation shows the percentages of the number of articles contributed by the workers of different countries based on the references in the periodicals in which the writings were first published. These percentages are as follows: Germany 50 per cent, France 16.3, England 12.2, United States 6.6, Russia 5.3, Italy 4.9, joint (in which investigators from different countries took part) 3.0, Japan 0.7 and Canada, Scotland, et al. in disappearingly small amounts.

Thus it appears that of the investigations dealing with the equilibria of alloy systems some 50 per cent have been the result of Teutonic labors. The position of the United States standing slightly ahead of Russia and Italy is somewhat painful to contemplate. In only the work on the iron-carbon system have the investigators in this country stood out prominently. It would seem in the light of the immense practical value of the metallic alloys as though more work would have been performed in the United States. There is no doubt a great deal more research going on at the present time than the aforementioned record would indicate, but some of it is unquestionably suppressed and does not find its way into the scientific press in anything like due season.

I have in mind a paper read before one of the societies not long ago which was then given out a number of years after the subject discussed had been in successful operation. The item alluded to was fully protected by patent as well as a strong corporation, yet the cause of delay was "for commercial reasons." It is presumed that the wide publicity which research requires will be secured with passing time.

Cleveland, Ohio.

ROBERT J. ANDERSON.

The Application of Nitro-Aromatics in the Explosive Industry

To the Editor of Metallurgical & Chemical Engineering

Sir:—I have read with interest the article, "The Application of Nitro-Aromatics in Explosive Industry," by John R. Mardick in your issue of March 15, 1917.

I agree with Mr. Mardick that a commercial explosive having nitro-aromatics as a base has a bright future. However, he states: "No serious efforts have been made in this country to make explosives containing other than N.G. True, there have been spasmodic attempts here and there by amateurs," etc. This is not true, since commercial explosives of this class have been developed by experts and large quantities of them have been consumed. They did not succeed on account of financial difficulties, but, on the other hand, the explosive chemist concerned in their manufacture produced a wonderful product.

It is also natural that the manufacturers of nitroglycerin and its products do not look with favor on a product which can be manufactured more cheaply and which is much superior in many ways.

Washington, D. C.

T. B. MUNROE.

The Electrochemical Industries and Hydro-Electric Power on the Pacific Coast

To the Editor of Metallurgical & Chemical Engineering

Sir: The legitimate complaints of the electrochemical industries of Niagara Falls of a dearth of power, due to a seemingly short-sighted policy as to water diversion of the Niagara River, might perhaps be somewhat tempered if these industries fully realized that in other parts of the United States there is available power—not potential power in the shape of water seeking a lower level, but actually developed electric power standing idle due to lack of demand for same.

The West has always been considered a breeding-place for optimists; and with true Western optimism some of the hydro-electric power plants have been overbuilt. They were installed with turbines and generators capable of producing power considerably beyond what seemed the immediate demands, with the hope that by the time the installations were finished there would be a demand for all the power. Such optimism has not always been rewarded, and to-day on this account there are available at various points on the Pacific coast close to 50,000 hp. on the switchboards. This power is obtainable at a price that should make many of the present power consumers in the East envious. The power is there—it is only a question of turning the water onto the wheels.

J. W. BECKMAN.

Beckman & Linden Engineering Corp.,
San Francisco, Cal.

Air Drying

To the Editor of Metallurgical & Chemical Engineering

Sir:—In my article on "Air Drying," in your issue of Feb. 15, in the last line on page 188, the boiling temperature of ammonia should be —33.7 deg. C. instead of —3.7 deg. C. It is an evident typographical error, as the temperature is given correctly in Fahrenheit degrees.

Philadelphia, Pa.

CARL HERING.

More About the Rat Problem

I.

To the Editor of Metallurgical & Chemical Engineering

Sir: I read in your paper of February 1 what you say about rat skins. I am a young man just starting out in life and I would like very much to go into business for myself. I know where there are a great many rats and if I could get ten cents each for them I could do better than I am doing now, although I have full charge of filing some of the daily reports in an insurance office. I hope you will excuse me for asking the question, but I could not quite make out whether you were in earnest or not, because you sometimes say, "Rats" when you mean a joke. If there is such a factory that tans rat skins will you please let me know, because I would like very much to catch rats and sell the skins for ten cents apiece.

Yours truly,

REGINALD HAROLD SALTASH.

* * *

II.

Women's Work Extension Bureau

To the Editor of Metallurgical & Chemical Engineering

Sir: Please give by return mail full particulars of ratskin leather business lately referred to in your journal. We do not propose that women shall catch,

murder or skin the rats, but we have in mind a group of women who are disposed to take full charge of selling the skins to the tannery provided the skins are not too smelly,

Yours truly,
(Miss) MARTHA L. PEPPERTON,
Corresponding Secretary.

* * *

III.

editor metulgical and chemal engeering

dere sorr i can furnish yo with rat skins i send about 150 or 200 to yo nex month.

yorse truly,

H. HORNER.

* * *

[We shall consider these letters seriatim:

I.—We are pleased with Mr. Saltash's communication because we always like to hear of ambitious young men. At the same time we are distressed to think that he should regard us as being frivolous of mind. No, Reginald, we were wholly in earnest. We do not like rats and we wish the country well rid of them. That is why we entered into conference with the best leather chemist we know and induced him to study the economy of the problem. It is his judgment that the skins would be worth at least ten cents apiece. It was his decision that the industry would be profitable if 5000 skins a day were assured. We are disposed to say that since you are in the insurance business, here is your chance, but you might think we were joking again and this is just what we want to avoid. Being somewhat heavy in build and ruddy in countenance we have constantly to fight against this error, this suspicion, that we are engaged in efforts of mirth the while we are striving to bring forth the truth. We shall not attempt, however to burden you with our secret sorrows. Take it for granted, please, that we never say rats when we mean a joke.

To return to the more familiar subject of assurance or insurance, we shall now repeat that here is your chance. It is the one problem unsolved. The tanneries are in sore straits for lack of hides. The complaint is general of what amounts almost to a leather famine, and lack of hides is the only reason for it. And here, according to the hypothetical census, are a hundred million rats, and every one of them with a hide. It is only a question of catching the rats, "murdering" them, skinning them and then salting or drying the skins—and the rest is easy. All that is required is the mind of a captain of industry and with this the whole problem is as good as solved. Go to it, Reginald Harold Saltash! We believe in you. There is not only wealth in it, but fame. St. Patrick drove the snakes out of Ireland and look at his reputation to this day, a thousand years after his death! The United States is a bigger country than Ireland, and the man that drives the rats out of it will surely be a hero. There'll be big bronze effigies of you, lad, in the public squares, and thousands of little Reginald Saltashes crying glory, hallelujah to the honor of your name, the livelong night. We wish you all success. Then, when you have the matter in hand and are as rich as New Jersey Zinc, we hope you'll call in and pass the time o' day with us. We shall be glad to see you.

II. Our answer to Miss Martha L. Pepperton, corresponding secretary of the Women's Work Extension Bureau, is to refer her to Mr. Reginald Harold Saltash, who is, we understand, giving the matter of ratskin brokerage his serious attention.

III. Mr. H. Horner suffers from the same defect as do his fellow correspondents; he does not read carefully. We never offered to buy ratskins and we enter

here a flat contradiction of one of his statements: He shall not send us about 150 or 200 next month. That is, he may send them, but they will not reach us. The head porter has instructions to smell carefully every package that is delivered, and if at any time he smells 150 or 200 rats or parts thereof, within the parcel, he is to forward it straightway back to H. Horner or to the Dead Letter Office.

We do not want to shirk our duty, but we think we have done our share in connection with the rat problem.]

Coming Meetings and Events

American Chemical Society, spring meeting, Kansas City, Mo., week of April 9, 1917.

American Electrochemical Society, spring meeting, Detroit, Mich., May 2-5, 1917.

American Iron and Steel Institute, New York, May 25-26, 1917.

American Society for Testing Materials, Atlantic City, June 26-30, 1917.

Third National Exposition of Chemical Industries, Grand Central Palace, New York, week of Sept. 24, 1917.

American Institute of Metals and Foundrymen's Association, Boston, week of Sept. 24, 1917.

American Electrochemical Society, autumn meeting, Pittsburgh, Oct. 3-6, 1917.

American Institute of Mining Engineers, annual meeting, St. Louis, Oct. 8-13, 1917.

Nitro-Starch as an Explosive

By S. S. Sadtler

High explosives, like many other things, are of great importance for the operations of war and the pursuits of peace. The manufacture of high explosives, however, has grown very greatly in this country during times of peace alone, and the development of the manufacture of commercial high explosives which took place before the present war is likely to be distanced after the war. This forecast is based on the new avenues that had been barely laid out just before the upheaval.

High explosives for commercial uses (mining, blasting, etc.) and excluding all applications for use in ammunition such as smokeless powders, have had a rapid development in recent years. The United States Government bulletins show that while in 1890 but 30,626-738 lb. of all grades of high explosives were used for such commercial purposes, 85,546,456 lb. were so used in 1900, 130,920,829 lb. in 1905, 204,763,299 lb. in 1910, and 244,151,789 lb. were so used in 1915, while nearly 15,000,000 lb. were exported.

Of the 1910 amount, 9,607,488 lb., and of the 1915 amount, 25,697,818 lb., are what is called "Permissible Explosives," specially prepared for use in coal mines. This class of products was practically unknown prior to 1902, in which year but 11,300 lb. were used. These permissible explosives are rapidly supplanting the use of black blasting powder in a large field, as the following statistics clearly indicate: Black blasting powder used in 1913, 229,939,525 lb.; 1914, 206,099,700 lb.; 1915, 197,722,300 lb. It should be noted, however, in this connection that the coal production was the largest of any year in 1913.

This rapid growth of the use of commercial high explosives was, however, in the well-known and established field of mining and quarrying, but an additional field is now being very rapidly opened for them and

the uses here are capable of almost unlimited development. This field is the application of high explosives in land tillage, tree planting, and a wide range of agricultural applications, all of very recent development. In 1914 nearly 30,000,000 lb. were used in this field, and as yet only a small portion of the farming element really know of these possibilities, and a still smaller number use them. However, the growth in this direction has been very rapid and the amounts to be utilized a few years hence, when the benefits are fully made known by the agricultural journals and the Government bulletins will be enormous. This is appreciated by the explosives manufacturers, and every effort is now being made, especially by the Du Pont Co., to bring it to the attention of the agricultural community by means of illustrated booklets and circulars. The United States Department of Agriculture is also sending out many Farmers' Bulletins devoted to disseminating knowledge on this subject.

The application of high explosives to mining and general commercial purposes may be said to date from the discovery of Nobel that nitro-glycerine could be mechanically absorbed in kieselguhr and then handled with a sufficient degree of safety to warrant its use. The product was called dynamite, but this name now applies broadly not only to nitro-glycerine absorbed by other inert materials like sawdust, mica-powder, etc., and to mixtures of the same with yet other ingredients both inert and active (the latter may be combustible like sawdust or oxygen furnishing, like nitrates), but it also applies to various high explosives containing no nitro-glycerine. The different strengths of high explosives, 20, 25, 30, 35, 40, 45, 50 per cent and up, are measured by the amount of nitro-glycerine there would be in a straight nitro-glycerine dynamite of equal strength.

At present there are an infinite number of chemical mixtures aiming to meet the different working conditions. By the solution of gun-cotton or nitrocellulose in nitro-glycerine (in which it readily dissolves, forming a jelly-like mass), we obtain blasting-gelatine, gelatine-dynamites, indeed other ingredients may be and are admitted. Low-freezing dynamites are also obtained by the addition of the allied liquid nitro-derivatives. Gun-cotton (or the higher cellulose nitrate) has not been found to be applicable by itself for the field of commercial blasting and mining explosives, except for submarine blasting where the compressed gun-cotton finds a use, as it is too bulky in comparison to its weight for other work.

The ideal high explosive should have the following qualities:

First—It should be of great strength and capable of reduction and also of speed regulation.

Second—It should be safe to make, transport and use.

Third—It should be compact, while plasticity is also very desirable in some cases.

Fourth—It should be unaffected by low temperatures.

Fifth—It should keep well without deterioration.

Sixth—It should emit no dangerous or noxious fumes and should be smokeless after firing.

Seventh—It should be low in cost.

Eighth—It should be waterproof.

I am now coming to my subject. Heretofore the chief substance for commercial high explosives has been nitro-glycerine, but there are serious inherent drawbacks to its use and, for some time, beginning even before the European war, the price has been mounting. This was due to the greater growth of demand for glycerine than the increase in supply.

For some time there has been an earnest effort put forth to find a satisfactory substitute for nitro-glycerine

dynamite, but without real success until recently, when great improvements in the manufacture of nitro-starch and the invention of a suitable container for the use of nitro-starch explosives, for commercial mining and blasting, has, it seems to the writer, placed nitro-starch where it is now capable of replacing nitro-glycerine explosives almost entirely for commercial purposes such as mentioned above.

Starch, which has an analogous chemical composition to cellulose and forms corresponding nitrate esters, was early suggested as the basis of a high explosive, having all the advantages of cotton without either its bulk, or higher cost. Marshall in his work on explosives says, however (page 173): "In spite of the cheapness of the raw material, starch, it (nitro-starch) has never been able to displace nitro-cotton; this is partly due to the instability of nitro-starch and partly to the mechanical difficulties in nitrating and purifying it." Similarly, Escales, a well-known German authority on explosives, says in his work "Die Schiessbaumwolle," 1905 (page 273): "Nitro-starch has so far found but little practical application; the reason for this is to be found in the insufficient stability, in particular of the high nitrated products, and above all in addition, the great hygroscopicity of nitro-starches." Marshall, however, records the production of a relatively stable nitro-starch with 14.04 per cent N, but says after describing the process for its manufacture, "Such a process is of course quite unsuitable for use on a commercial scale, but it seems to indicate that nitro-starch itself is fairly stable if it can be separated from impurities." These impurities from the standpoint of nitration, are natural to the starch.

There are impurities in even the best commercial starch. I have been chiefly concerned with the use of maize or corn-starch, and the impurities to be considered are moisture, nitrogenous substances, fatty acids, phosphates, and probably lecithins which may account for the presence of more or less of the fatty acids, phosphates and nitrogenous substances present in starch. Of course there is an envelope of cellulose around the starch substance, but for purposes of nitration this presents no drawback. The starch substance itself is probably complex physically and molecularly, but essentially it is either $(C_6H_9O_5)_n + H_2O$ or $(C_6H_7O_4)_n$, where n represents a large integer in either case, and different values of n may account for what grounds there are for the belief in the complexity of the starch substance. The starch substance itself is certainly colloidal and the problem must be attacked along these lines.

With regard to the amount of nitration, there have been various hypotheses made as to what is possible. Hough (U. S. Patents 751,076 and 790,840), claimed as high as 16.5, but if this amount of nitrogen can be fastened to the carbohydrate nucleus, it is in too unstable a condition to be of any practical importance and I am inclined to believe that a tri-nitrate $(C_6H_7(NO_3)_3O_4)_n$ with 14.14 per cent N is the limit of a possible stable nitrate, although its attainment is difficult. In following my process (U. S. Patent 1,211,761) I have never attempted to secure a higher nitration than 13 to 13.3 and do not believe a nitro-starch can be stable with as much nitrogen as would be found in a full tri-nitro-starch, or, if the molecule is taken as $(C_{12}H_{20}O_{10})_n$ a hexa-nitro-starch. Some of the nitro substitution products are so unstable that they must be decomposed and removed in the processes of purification so that their later decomposition does not cause the decomposition of the main portion of the product. These unstable products are probably higher nitro substitution substances and products of side reactions.

Nitro-starch is an ester or an organic salt of an acid radical and a derivative of the alcohols. Hydrogen of the OH groups of the starch carbohydrate or carbohydrates is substituted by NO_2 groups from nitric acid. Like the esters, decomposition may be effected readily, if indeed it may not be said that there is a tendency to dissociate. Both acids and alkalis are active agents in causing decomposition. The rapidity of decomposition with acids is a function of the time, quantity and temperature for any particular acid or alkali. Now, there is no stronger acid than nitric; in other words, no more highly ionized acid, and sulphuric is nearly as strong. Therefore, as the nitration is effected by nitric acid rendered anhydrous by strong sulphuric, traces of nitric and sulphuric acids must be as near completely removed as possible. It might seem to the uninitiated as if this were quite easy, but due to the dense colloidal character of nitro-starch this is quite difficult to effect. Nitro-starch is very much denser than nitro-cellulose, as a given weight of the former occupies a very much less space than nitro-cellulose even when the latter is under great pressure.

Nitro-starch by my patented commercial process with 13 to 13.5 per cent nitrogen—1 lb. dry starch—produces $1\frac{1}{2}$ lb. Nitro-starch, S. G. 1.57, Abel Test 175 deg. F. 30'. Sv. Stability test at 165 deg. C. 1' 35". Combustion test 182 deg. C. At 135 deg. not exploded in 30'. KI and Starch test 65 minutes at 70 deg. C.

Nitro-starch is insoluble in water, even in boiling water, wherein it differs from corn starch. It also differs from corn starch in being soluble in some organic solvents such as acetone and amyl acetate. The structure is unchanged in nitration although the grains are somewhat swollen. The color is practically unchanged if the nitration is properly carried out and the water available is satisfactory. Nitro-starch is very analogous to nitro-cellulose. It, however, is much denser. In ordinary condition it only occupies about one-fifth the volume of nitro-cellulose. This is before treatment with organic solvents. When treated with solvents for the purpose of colloiding, which solvents are afterwards evaporated, it has about the same bulk as nitro-cellulose in its colloided form, but differs from it quite markedly in its properties, as it does not form as tough a colloid as nitro-cellulose.

For blasting this material has a great many advantages, although some prejudice might have to be overcome in some cases. It is in the first place safe, due to the fact that it cannot be accidentally exploded except by exploding a cap in contact with it. It gives off no bad fumes in mining tunnels when reasonably well compounded. The fumes, under no circumstances, produce headaches, and have seen men go right into the tunnels after firing it, although, of course, this is not advisable. In mining use it is known for its quick and short flame. It is non-freezing.

At a higher temperature, 79.4 deg. C., the results in a few cases were as follows:

Nitrogen Contents.		Stabilities.
13.55 per cent.	....	Abel Test at 79.4 deg. C. 25 min.
13.14 per cent.	....	Abel Test at 79.4 deg. C. 30 min.
13.00 per cent.	....	Abel Test at 79.4 deg. C. 32 min.

A quantity made over ten months previously showing no deterioration from its original stability.

This nitro-starch stands the International test for 48 hours at 75 deg. C. with a loss of 0.5 per cent in weight and no red fumes. Better results than any here given have been found where the product had exceptional washing.

A sample that stood the Abel test at 79.4 deg. C. for 20 minutes was then subjected to the International Test for 48 hours at 75 deg. C. with no apparent loss of N.

This sample was then again subjected to the Abel Test at 79.4 deg. C. for 18 minutes before the slightest sign of discoloration appeared on the starch paper.

Nitro-starch differs from nitro-cellulose in its density. The real specific gravity is 1.55 to 1.60, but its apparent specific gravity is what really counts as it is naturally so dense that it can easily and cheaply be compacted for use in cartridges for rock blasting which cannot be done very well with nitro-cellulose.

One important property of nitro-starch is that it takes so little solvent to dissolve it (sometimes called colloiding). This militates against it for use in lacquers, but in making plastics for wet rock blasting it is greatly to its advantage. To make a gelatine dynamite with nitro-cellulose it requires about 5 to 6 per cent nitro-cellulose to make a pasty mass, and about 80 to 85 of nitro-starch. As nitro-starch is cheaper than and yet as powerful as nitro-glycerine, while nitro-cellulose is more expensive, it can readily be seen how desirable nitro-starch is for this work.

Quite a little has been said about the hygroscopic character of nitro-starch. I can only say that what I have produced by my process would not be considered hygroscopic. All fine powders will attract some moisture, generally measured in tenths of a per cent, and nitro-starch does not do more. Several times I have found some that had been freely exposed indoors in summer and winter to have from 0.2 to 0.3 per cent moisture. Personally I would not expect it to be hygroscopic as it has organic solvents for its solutes and not water. A condensed comparison of nitro-starch and nitro-glycerine may be given as follows:

DYNAMITE

A. Disadvantages:

Dangerous to shock.
Highly injurious fumes, causing headache and sickness.
More or less sensitive to changes in temperature, according to grade and composition, most grades easily freezing in cold weather.
Cost: High at present and likely to remain high as compared with previous prices, even after the war.

DYNAMITE

B. Advantages:

Compact.
Plastic.
Effective because many years of experimentation have given it adaptability.
Non-hygroscopic and little affected by wet situations.
Good stability.

NITRO-STARCH

A. Disadvantages:

Not plastic in natural state although can be made plastic if desired.
More bulk than dynamite unless artificially compressed.
Rendered temporarily inert when in powder state by wetting.

NITRO-STARCH

B. Advantages:

Not in any way sensitive to shock, or in fact cannot be exploded in any other way than with a fulminate detonating cap. Even fire will not explode it.
May have good stability.
Effective when properly prepared for a wide range of usefulness, possibly as great as that of nitro-glycerine powders.
Does not have injurious fumes.
Its lightness when not specially compacted is advantageous for many purposes.
Is not sensitive in any way to changes of temperature.
Is non-hygroscopic.
Will undoubtedly be the cheapest organic-explosive.

One of the chief points of merit in the use of nitro-starch is its cost. It can readily be seen that if there is no special difficulty in the manufacture, and there is none, that its being made from a base costing $2\frac{1}{4}$ to $2\frac{1}{2}$ cents a pound, as compared with glycerine at 30 to 60 cents a pound, or cellulose rising of 10 cents, that

there is great economy in its use. We can say that we not only feel that it is as easily manufactured as nitro-cellulose when the cost of the bases is not considered, but that for reasons of simplicity in handling and time of nitration, it is more economically manufactured than nitro-cellulose.

The field of commercial high explosives or blasting powders is so much greater than that of ordnance in normal times that it is hardly necessary to consider them in looking up this new line of manufacture. We might say, however, besides its use for blasting that it seems to offer special advantages for torpedoes for under-water or aerial use. This is due to its compactness and high explosive power. For such uses or for grenades it would have to be detonated by fulminated mercury, as there is no other way that we know of for exploding it. Shock alone will not do it, nor will fire alone do it.

The writers associates patented an expanding waterproof cartridge which greatly adds to the improvements in nitro-starch alone. The cartridges ordinarily used for high and permissible explosives are of paraffined paper made into cylinders (of the diameter required), either wrapping straight or spirally with the ends either turned in roughly and dipped in paraffine, or where made by the latest devices the ends are crimped in (similar to a shot-gun cartridge) and also dipped in paraffine. In the use of these paper cartridges, say for drill holes, it is customary to have them of the same diameter as the steel drill head so that they will not stick and can be loaded right back to the ends of the holes, for the torque of the drill-iron in drilling the holes, considerably enlarges its diameter, a 1" drill making a 1 1/4" hole. It is thought absolutely necessary to have the diameter of the hole completely filled with the explosive to be used in order to fully utilize the strength of the explosive. Therefore it is customary to slit the paraffine paper cartridges lengthwise two or three times with a knife, insert slit cartridge in the hole, sliding it back with a wooden tamping rod till it grounds on the end of the hole and pressing it till it opens up, shortens, and more nearly fills the hole (but exposes its contents). Others where required are introduced in like manner except the last which is not slit, but the detonator inserted and tied in, slid up to the last cartridge and then tamped. The serious disadvantages encountered are that it is somewhat dangerous to slit most explosives with a knife, it exposes the contents to any dampness and in the case of non-plastic explosives in rising holes prevents their use, and in the case of both plastic and non-plastic explosives is liable where there are fissures in the rocks to cause a leakage where it may later be the cause of an accident. In ascending holes (raises) if one should slit an ordinary nitro-starch cartridge and try to tamp

it into place (push it up the drill-holes as far as possible and then some) a good deal of the powder will rain out on the miner.

Most cartridges must not be slit in wet holes, but we have produced a cartridge remedying these difficulties, the patent for which has just been allowed for the United States. It consists of an inner paraffined paper container that can be expanded when in place in the hole, completely filling it without slitting and exposing the contents, and is waterproof, and an outer container to keep it in shape in transportation and handling, to be very quickly removed without the use of a knife when the cartridge is to be used. This cartridge, inner and outer containers complete weighs 1/5 of an ounce as against 1/2 ounce for the cartridge now on the market, and with the outer container removed ready to fire .16-1/3 of an ounce. It is desirable to load drill holes with explosives not paper, for paper represents loss of power, loss of oxygen and added smoke. This cartridge should cost little more than that now in use.

We feel that with the properties of nitro-starch in mind, one can form some idea of the military and naval uses therefor. We can only give our prediction of the future of nitro-starch.

We know that nitro-starch has a great field in both military and naval use, being preferable to gun-cotton wherever it is used uncolloided for the following reasons: greatly increased weight per bulk (admitting of larger charges in mines, torpedoes, hand-bombs, grenades, etc.), greater stability, less liability to spontaneous combustion, and great reduction in cost. It is very much cheaper than tri-nitrotoluol.

We believe from the crude tests to which we have been enabled to subject nitro-starch that it will stand being fired from large guns as the exploding contents of explosive projectiles if compounded slightly. Under the proper conditions this could be quickly ascertained.

In conclusion I would say that nitro-starch will make satisfactory forms of the many commercial explosives desired to be manufactured on a large scale and sold for what it is, "nitro-starch explosive." For military purposes it will be found useful, as it may be readily made stable without the addition of dope, and it is compact, powerful and cheaply made.

Philadelphia, Pa.

Industrial Activity Along a Southern Railroad

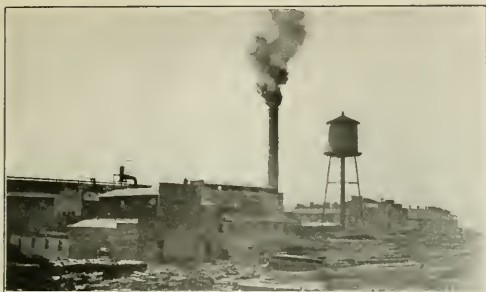
For the adjoining illustrations showing a number of industrial plants along the Carolina, Clinchfield & Ohio Railroad we are indebted to Mr. Charles F. Roth, one of the managers of the annual chemical exposition in New York, who took these photographs during a recent visit to the South.



FEDERAL DYESTUFF AND CHEMICAL COMPANY,
KINGSPORT, TENN.



SOUTHERN POTTERIES, INC., ERWIN, TENN.



KINGSPORT EXTRACT CORPORATION, KINGSPORT, TENN.

KINGSPORT, TENN., CLINCHFIELD PORTLAND CEMENT CORPORATION, KINGSPORT PULP CORPORATION
IN BACKGROUND

That a railroad builds up a country, is an old story. But the results which the Carolina, Clinchfield & Ohio Railroad has attained in the last few years in building up new industries with marvelous rapidity, are unprecedented at least in the South. And absolutely novel anywhere is the extent to which the advice and help of the chemical engineer has been sought in this work by the progressive president of the road, Mr. Mark W. Potter, resulting in the creation of a growing industrial center with a certain chemical individuality.

The road operates in five States from Elkhorn City, Ky., to Spartanburg, S. C.

Erwin, Tenn., the division point of the line, is one of the centers of activity. There are at this place the Southern Potteries, Inc. (Southland and Dixie being two important brands of fine tableware of their make), the Clinchfield Products Corporation (mining feldspar), an automobile spoke factory, and a silk mill of A. P. Villa & Co. The Holston Corporation which has large holdings in the city is laying out a city beautiful through Grosvenor Atterbury of New York.

Kingsport, Tenn., is another very lively new industrial center. There is the Clinchfield Portland Cement Corporation with a monthly output of 100,000 barrels. A lime plant has just been built by Mr. R. K. Meade, of Baltimore, to make lime for this company and shortly it is expected to burn dolomite to be converted into lime and magnesium carbonate and possibly magnesia at the Federal Dyestuff & Chemical Company's plant.

Lime will also be supplied to the Kingsport Tanning Corporation which co-operates with the Kingsport Extract Corporation, making 25 tons per day of tanning extract. The daily output of the tanning company is 100 hides.

The Kingsport Pulp Corporation is to use the spent chips and wood shavings from the Extract Corporation and make them into paper pulp by the soda process, and paper is made by the Kingsport Paper Corporation.



KINGSPORT BRICK CORPORATION, KINGSPORT, TENN.

The Kingsport Brick Corporation has 28 kilns, with a daily output of 130,000 brick. Sewer pipe is soon to be another of their products.

The Federal Dyestuff & Chemical Company, the product of the genius of Dr. John C. Hebden, has been in operation since January, 1916, and is now producing forty different dyes.

The DeCamp Glass Casket Company will shortly start operation at Kingsport, using fine glass sands from the local hills.

Coal comes for the various industries on the Carolina, Clinchfield & Ohio R. R. from Clinchfield, Va. The dye plant is getting salt for manufacture of caustic soda and chlorine from C. C. & O. property, and so on.

This whole industrial activity has already developed many of the district's natural resources, though more remains to be done. The fact that the Kingsport valley industries are almost self-contained is one of the noteworthy economical features of the whole development.

Properties of Metals and Alloys

The Bureau of Standards is undertaking very useful work in a systematic endeavor to collect the most reliable information available on the properties of metals and alloys.

As an illustration of the information wanted the following list of the properties of copper is given, but criticism of the constants for copper is desired.

Name of metal or alloy: State or condition	Cast	Annealed	Hard Drawn	Remarks
Chemical composition and impurities	99.90% Cu, 0.08% O ₂ , 0.002% Ag, 0.003% Fe	0.002% O ₂ , 0.003% Fe		
Density, g. per cm. ³	8.93	8.93		
Shrinkage coefficient, ϵ_v	1.42			
Tensile strength, lbs. sq. in.	20-30,000	30-40,000	40-60,000	† Ranges of commercial variations
Yield point, lbs. sq. in.				
Elastic limit, lbs. sq. in.				
Elongation in 2", %	30-50	40-60	4-5	
Reduction of area, %	30-50	40-60		
Brinell hardness, H. N.	30-40	30-40	80-100	
Scleroscope hardness		6-7	22-24	
Behavior in compression.				
Frictional coeff. (steel)				Yields indefinitely and flattens out
Abrasion resistance				
Melting range, °C. or °F.	1083.0°C.			
Coeff. of expansion, per °C.		0.0001666		
Specific heat, cal. per g. degree		0.0917 (25°C.)		
Thermal conductivity		3.73 (— watt seconds cm.—second — degree C)		
Electrical conductivity, ohms (meter, gram)...	30-90%	100% = 0.15328	96-97%	
Temp. resistance coeff. per degree C...		0.000393		
Resistance to corrosion				
Hydraulic properties				
Optical properties, emissivity for $\lambda = .63\mu$				(For liquid (1100°C.) = .150 (For solid (1080°C.) = .117
Miscellaneous (including any other known property)				

Analogous information is desired on other metals and alloys and it is hoped that this collection of data will render generally available the most acceptable values of such constants and may also serve as a basis for further experimental investigation. In each case the numerical values should be representative of and fair to the material for technical practice, rather than special values, as for instance the highest tensile strength, etc., that may be obtained.

Other points which are to be taken into account in the compilation of these data are as follows:

The chemical composition should be known to apply strictly to the alloy for which properties are given.

The state of the metal as cast, annealed, forged, rolled, etc., should be given in as great detail as possible.

The authority or source for all numerical values should be given.

The limits or tolerances which should be allowed or expected in practice for any constant should be given.

When possible and known, the variation with temperature of any property should also be given.

Data on the effect of impurities on any of the physical properties of any metal or alloy are important.

Some of the alloys for which data are desired are the following: Aluminium and its light alloys with zinc, copper, etc., of stated percentages; nickel, Monel metal, and copper-nickel alloys; aluminium bronzes, such as Al7—Cu93, Al10—Cu90, etc.; manganese bronzes, cast and wrought; phosphor-bronzes, such as Cu80, Sn12, Pb7, P1, etc.; Muntz metal, naval brass, Tobin bronze, and brass of 60Cu—40Zn; yellow brass of 70Cu—30Zn, the red bronzes and other bronzes; bronzes of 90Cu—10Sn, 88Cu—10Sn—2Zn, 88Cu—8Sn—4Zn, and their modifications with Pb and Fe added, etc.; bearing metals; white metals, etc.

Waterpower Decision of U. S. Supreme Court

The recent decision of the U. S. Supreme Court in the case of the Government versus the Utah Power & Light Company is noteworthy as it settles a principle of great importance to all states having public lands the development of which has been retarded by uncertainty as to the interpretation of federal laws. The question in doubt has been whether the congressional act of 1866, giving rights-of-way over government land for the use of water for beneficial purposes has been repealed by later acts of Congress by which the use of rights-of-way over government land is restricted to revocable liens and easements issued by the Department of Interior or Agriculture. This question is answered in the affirmative by the present U. S. Supreme Court decision in favor of the Government.

From this decision which was written by Justice Van Devanter, we quote the following:

"We are concerned here with three suits by the United States to enjoin the continued occupancy and use, without its permission, of certain of its lands in forest reservations in Utah as sites for works employed in generating and distributing electric power and to secure compensation for such occupancy and use in the past. The reservations were created by executive orders and proclamations with the express sanction of Congress. Almost all the lands therein belong to the United States and before the reservations were created were public lands subject to disposal and acquisition under the general land laws. The works in question consist of diversion dams, reservoirs, pipe lines, power houses, transmission lines and some subsidiary structures."

"In occupying and using the government lands as sites for these works the defendants have proceeded upon the assumption that they were entitled so to do

without seeking or securing any grant or license from the Secretary of the Interior or the Secretary of Agriculture under the legislation of Congress, and, in truth, they have neither applied for nor received such a grant or license from either. But, notwithstanding this, they assert that they have acquired and are invested with rights to occupy and use permanently, for the purposes indicated, the government lands upon which the works are located."

"The first position taken by the defendants is that their claims must be tested by the laws of the State in which the lands are situated rather than by the legislation of Congress." . . . But "state laws, including those relating to the exercise of the power of eminent domain, have no bearing upon a controversy such as is here presented, save as they may have been adopted or made applicable by Congress."

"The next position taken by the defendants is that their claims are amply sustained by Nos. 2339 and 2340 of the Revised Statutes, originally enacted in 1866 and 1870. By them the right of way over the public lands was granted for ditches, canals and reservoirs used in diverting, storing, and carrying water for 'mining, agricultural, manufacturing and other purposes.' The extent of the right-of-way in point of width or area was not stated and the grant was noticeably free from conditions. No application to an administrative officer was contemplated, no consent or approval by such an officer was required, and no direction was given for noting the right-of-way upon any record. Obviously this legislation was primitive. At that time works for generating and distributing electric power were unknown and so were not in the mind of Congress. Afterwards when they came into use it was found that this legislation was at best poorly adapted to their needs. It was limited to ditches, canals and reservoirs, and did not cover power houses, transmission lines, or the necessary subsidiary structures. In that situation Congress passed the Act of May 14, 1896, c. 179, 29, Stat. 120, which related exclusively to rights of way for electric power purposes and read as follows:

"That the Secretary of the Interior be and he hereby is authorized and empowered under general regulations to be fixed by him, to permit the use of right of way to the extent of 25 ft., together with the use of necessary ground, not exceeding forty acres, upon the public lands and forest reservations of the United States, by any citizen or association of citizens of the United States, for the purposes of generating, manufacturing, or distributing electric power."

"We regard it as plain that this act superseded Nos. 2339 and 2340 in so far as they were applicable to such rights of way."

Alcohol from Calcium Carbide.—Works for the manufacture of alcohol from calcium carbide are contemplated in Switzerland at a cost of 9,000,000 francs (about \$2,250,000). The works will require one and a half years to finish. The Lonza Electric Company applied for a license and it was considered in February by the Bundesrat. This concern was the only one to obtain a license. Alcohol for industrial purposes is the primary object, but it is possible to make this alcohol into drinking spirit. There is ample raw material in Switzerland for this industry. The concession is to run for a definite period, and during a certain time no alcohol may be exported. On that account storing facilities must be provided. About 55,000 to 60,000 meterzentner (1 meterzentner = 100 kg.) of alcohol for burning purposes have been required annually in Switzerland. The works will be erected at Visv and will constitute a large new industry.



NEW CHEMISTRY BUILDING, UNIVERSITY OF CINCINNATI

Metallurgy and Electrochemistry at the University of Cincinnati

Ernest Edgar Thum,
Assistant Professor of Metallurgy
AND

Albert Watson Davison,
Assistant Professor of Physical Chemistry

The completion of the new Chemistry Building at the University of Cincinnati prompts a description of the activities of the electrochemical and metallurgical departments in this institution. As a matter of course the chemistry department serves the various other departments of the university in offering the usual subjects in elementary and advanced chemistry to students in the liberal arts, medical and other colleges. A large amount of the equipment of the new building is therefore utilized by such classes; it differs somewhat from that in other institutions of like grade, but since it will be described elsewhere in considerable detail, it need not be discussed here.

The equipment installed to care for the needs of electrochemistry and electrometallurgy is unusually complete, however, and deserves more or less detailed description. Not only will the new building offer unusual advantages for the instruction of chemical and metallurgical subjects, but the manner of teaching them to students of the engineering professions is unique and worthy of description, even at the risk of repeating what has already appeared elsewhere.

Ten years ago the Dean of the Engineering College, Herman Schneider, started his "co-operative course" for engineers. In the intervening years it has passed through the formative stages, weathered the storms of financial panic, business depression and labor troubles, and to-day stands as a pronounced success, favorably noticed on every side. The Engineering College still offers the usual four-year courses leading to the degree of Bachelor of Science in chemical, civil, electrical, mechanical or metallurgical engineering, very similar in form and substance to corresponding courses given elsewhere. Of the 500 students registered in the Engineering College during the present academic year, however, 478 are pursuing the "co-operative" course, continuing through five years of eleven months, and leading to the degree of Chemical Engineer, Civil Engineer, Electrical Engineer, Mechanical Engineer or Metallurgical Engineer.

A student desirous of entering a co-operative engi-

neering course and who has satisfied the entrance requirements, presents himself at the university three months before the beginning of his freshman year. After an interview with the head of the course he is electing he is taken to some industrial plant which offers apprentice openings (with apprentice wages) nearest fitted to his capabilities. As an instance a metallurgical engineer may be cutting sand in a foundry, a chemical engineer may be trucking materials in a warehouse, a civil engineer may be working on a railroad section gang, etc.—in general, the work will be in his line, and as severe as he is physically capable of performing. Here he spends the three months intervening until the opening of his first school term, and during this time he must perform the duties of his job in a satisfactory manner in order to earn the right to matriculate. It is obvious that young men deficient in stamina will drop out of sight during this period—in fact, co-operative students seldom become in arrears in their shop work or are reported by their foremen as being unsatisfactory. Indeed, our pedagogical problems would be exceedingly simplified could we discover such a reliable, short-time test for determining their future *scholastic* capabilities.

At the beginning of school two metallurgical students are paired as "alternates" and assigned to some job, taking turns in the shop and in school, changing places each two weeks. In this way the employer has a workman continuously, while the school instruction is repeated for the benefit of the two sections of the class. The alternation between shop and school continues throughout the entire five years, the individual student being changed from one firm to another, and promoted from one job to a better as often as circumstances, expediency and his own ability permit. In general, it is aimed to spend the first year in an iron, steel or brass foundry, the second in a machine shop, the third in forge shops or heat treatment rooms, while the remaining may be spent in various locations in a steel plant, or pursuing some special line of metallurgical or metallographical work with smaller concerns. It is seldom that the student in any of the engineering departments spends the entire five years of his college course in one plant, as few in this vicinity are extensive enough to offer the diversified experience desirable, although the National Cash Register Company of Dayton, Ohio, has worked out some excellent shop courses for co-operative students in their employ, and a large chemical manufacturer of Cincinnati has arranged a five-year course for chemical engineering students, starting as bottle washer and ending as research assistant.

The university profits through the co-operative course in being relieved of the necessity of maintaining the school shops—the practice work in all engineering branches is done by the student working as an employee in a modern industrial organization. The capacity of the school laboratories, drawing and class rooms is doubled, and the necessity of many detailed descriptive courses is eliminated.

The student profits through the co-operative course in being able to earn his living while in school. As a workman in a modern factory he develops industry, loyalty and self reliance. Best of all, he acquires through actual contact that intimate and detailed knowledge of the machines and men he will some day manage.

But for these benefits to accrue to both student and university it is necessary to develop and prosecute a close co-ordination between the theoretical subjects taught in school with the practical objects worked with in the shop. This all-important task is intrusted to a new department called the "Co-ordination Department." The freshmen working in foundries, for instance, meet in class three times a week, and there discuss with the

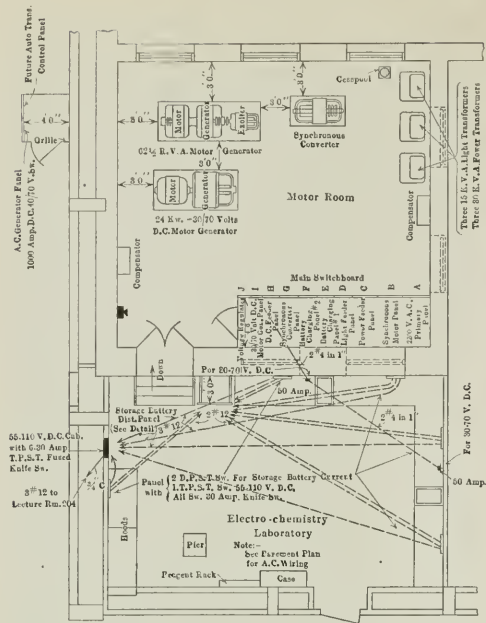


FIG. 1—PLAN OF MOTOR ROOM AND ELECTROCHEMISTRY LABORATORY

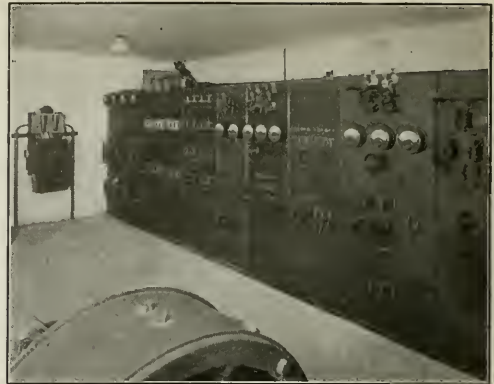


FIG. 2—FRONT OF MAIN SWITCHBOARD—DIRECT-CURRENT GENERATOR IN FOREGROUND

instructor in co-ordination various phases of their work. He asks questions of them designed to stimulate their powers of observation, and points out features of their work which have a direct or indirect relation to their theoretical studies. The interchange of information between student and student, and student and instructor serves to make the student a more intelligent, and therefore a more efficient workman, and to emphasize the instructional value of his shop work. As the student's character rounds out in the progress toward graduation, the individuals enter into more and more diverse pursuits, and co-ordination en masse becomes less and less practicable or necessary. But at all times some interested member of the university faculty is in touch with the student's shop work, this instructor visits the plants often enough to be familiar with the undergraduate's work and progress, and he meets his charges once a week in a clearing house for the exchange of engineering information.

The co-operative course, obviously, depends first of all upon the attitude of the employer—the managers of the

co-operating firms. The good will of these men is obtained chiefly because the arrangement is a profitable one for them. Even in his probationary period the co-operative student far excels the usual apprentice; further on in his course he is the equal or better of the mechanic at his elbow; and upon graduation he is available, trained in theory and practice, for the minor executive positions of the staff. In short, it is a step toward furnishing them with efficient employees. Of course, troubles sometimes have to be surmounted, but the net effect upon the employer is a growing realization of the advantages of employing co-operative students—of furnishing them with their "practical" education. Over seventy firms within a radius of fifty miles

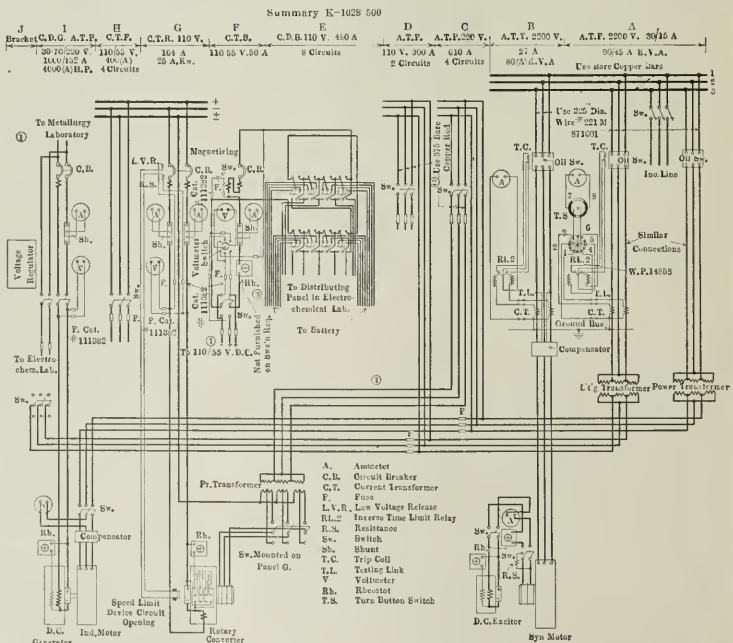


FIG. 3—WIRING ON REAR OF MAIN SWITCHBOARD

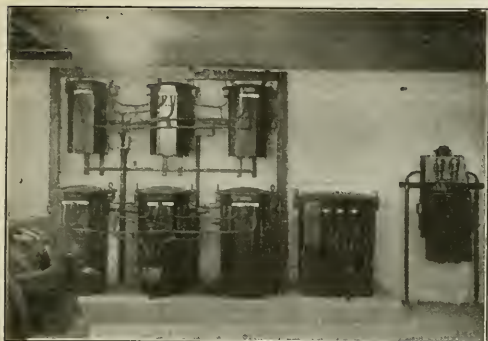


FIG. 4—TRANSFORMER BANK (COMPENSATOR FOR A.C. GENERATOR ON RIGHT, SYNCHRONOUS CONVERTER ON LEFT)

of Cincinnati are now employing these undergraduates, and unsolicited requests for more students than we can possibly furnish are continually being received from others.

That there are styles in engineering education like styles in ladies' millinery is possibly a truism. For this reason it is seen that the number of students in a given course will not correspond exactly to the requirements of the nearby industries—nor even approximately in equal measure. Fifteen years ago a high school student who did not aspire to become an electrical engineer was a rara avis, and a co-operative course (should one have existed at that time) would doubtless have been unable to place all the candidates in desirable shops. So it is at present. The isolation of Germany and the interruption of her exports of synthetic chemicals has caused a great agitation in the breasts of innumerable publicists who have forthwith urged upon young America the necessity of studying chemistry. The result is that courses in chemical engineering are very popular—subjects neglected a few years ago have ten to twenty times the number of registrants. Doubtless, in time, metallurgical engineering will feel the effects of some such advertising campaign, and more students will prepare themselves to supply the ever-growing and insistent demand for men who can scientifically control the metallic output of steel works, foundries, forge shops and heat treatment rooms. At present, chemistry has a plethora of students, while the metallurgical department can not supply the positions offered to it.

The co-operative course has caused a very radical alteration in the curriculum, as can be readily seen. For instance, it is unnecessary to describe ordinary molding methods to a man who has worked in a foundry for a year. Again, in the study of open-hearth steel production, we can describe the furnaces best by going to one of our co-operating plants and examining in detail a furnace, shut down for repairs. The chemistry of the process may best be studied by observing a heat from charging to tapping—obtaining weights, observing temperatures, and taking samples for later computation and analysis in classroom and laboratory.

Laboratory work in metallurgy is not eliminated. On the contrary, all engineering students (mechanical, civil and electrical) receive a strong course, covering one semester, in the metallurgy and heat treatment of iron and steel. This course is primarily a co-ordination course, in that it aims to explain the mechanical, physical and electrical properties of the various iron and steel products in common engineering construction by reference to fundamental chemical, physical and metallographical principles. A text is used by the student in home study, which is inclusive enough to contain descriptions of the modern metallurgical and mechanical operations between ore and finished product. The lecture course supplements this and attempts to make definite reference to the metallic materials the young men are handling in their shop work, or will use in later practice. It is remarkable what a variety of requests will come to the instructor to explain in detail some process of shop work. Finally, three afternoons each

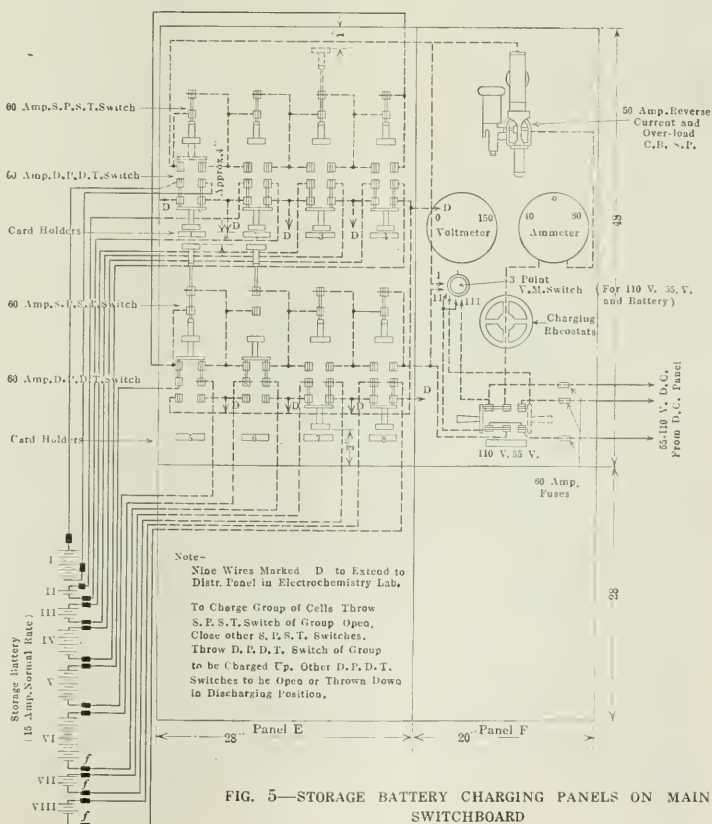


FIG. 5—STORAGE BATTERY CHARGING PANELS ON MAIN SWITCHBOARD

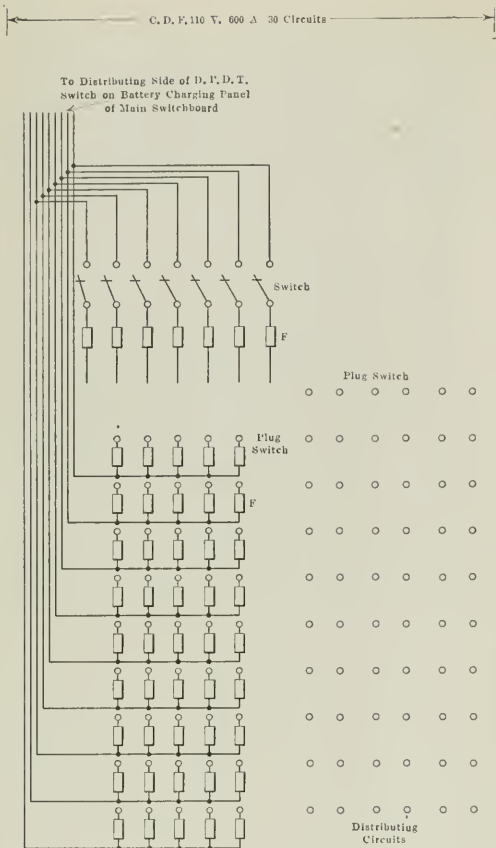


FIG. 6—SWITCHBOARD IN ELECTROCHEMICAL LABORATORY

week are spent in the laboratory, where the student makes his own pyrometer, calibrates it, studies a simple equilibrium system, leading up to tests confirmatory of the iron-carbon diagram, which is later utilized in hardening, tempering and annealing studies. From the experimental knowledge thus gained the student makes cold chisels, center punches, malleable castings and case-hardened pieces.

Electrochemistry, under the caption Applied Electrochemistry, is taken by students who are candidates for the degrees of chemical or metallurgical engineer. The course aims to familiarize the student with the theory and practice of such processes as deposition and electrolytic refining of metals; alkali chlorine electrolyses; fused bath electrolyses for the preparation of such metals as sodium, calcium, barium, magnesium and aluminium; electrothermic preparation of carborundum, calcium carbide, graphite; the preparation of such alloys as ferrosilicon and ferromanganese; the reduction of phosphorus, and the fixation of nitrogen.

Four lectures are given each week, supported by assignments in Thompson and in Allmand. One hour per week is reserved for quiz work. Twice during the course each student is assigned some electrochemical topic, which will necessitate a thorough search of the chemical literature. If a student has chosen an electrochemical problem for his thesis, one of these assignments will closely border on that subject. Laboratory

practice requires three afternoons per week; and since some of the exercises are of a more or less continuous nature, certain experiments may be under uninterrupted observation for from twelve to twenty-four hours.

Students who elect their major work in electrochemistry are also given a thorough theoretical training. This course covers the theory of electrolytic dissociation, migration velocities, transference numbers, electromotive force, single electrode potentials, ionic concentration and overvoltage. Classroom discussion is closely followed in the laboratory practice.

The electrochemical and metallurgical laboratories, situated on the first floor of the new Chemistry Building, each open into the power room, containing the generators and main switchboard (Fig. 1). The electrochemical laboratory is fitted with asbestine stone work tables, with lockers underneath, and with wall panel switchboards containing knife switches and wing binding nuts. Only experiments having small power requirements are performed in this laboratory. In the metallurgical laboratory, beside the usual gas and oil-fired furnaces which occupy the front half of the wing, are to be found the switchboard for electric furnace control, and floor space with a large 12-ft. by 20-ft. hood for electric furnaces.

It is not the aim of the department to maintain "hand-me-down" furnaces of every kind and variety; rather students are expected to construct their own from an abundant stock of electrodes and refractory materials. The plan suggested by Gillett and Lohr, of the Bureau of Mines, of mounting heavy oak platforms on large castors, and building furnaces on these, has been found excellent, as it permits the unit to be moved from place to place. In the case of arc furnaces, it also gives a substantial base for electrode control devices. The metallurgical department keeps ready for use two small arc furnaces, one of the Heroult and the other of the Girod type; and Electrochemistry possesses a 15-kva. vertical Arsem vacuum furnace. These are the only permanent pieces which present plans contemplate. In order to remove furnace fumes so far as possible, the hood above the furnace platform is exhausted directly to the open air by means of a 36-in. fan, driven by a 6-hp. motor. This device, therefore, has no connection with the general laboratory ventilating system.

Fig. 2 shows a view of the front of the main switchboard, while Fig. 3 gives the wiring diagram of the back of the same. In the study of the diagram notice that panel A at the right corresponds to the panel at the extreme left of the photograph.

In describing the generating units, more order will be doubtless brought out of chaos if the authors limit themselves to consideration of one unit at a time. Electrical energy is received from the university power house at 2200 volts, and is transformed in the power room to 110 volts for lighting, and to 220 volts for driving motors. Besides the lighting circuits, each laboratory is generously supplied with 110-volt alternating current for heating devices. Fig. 4 shows the transformer bank for lights, power and furnace work.

Direct current for lanterns, storage battery charging and general experimental purposes throughout the building is generated by a 25-kw. synchronous converter shown in the center of Fig. 4. Distribution from this machine is by the three-wire system from panel G; 110 volts being obtained from one combination of leads, and 55 from either of the other two permutations, 110-volt lines run to all offices, lecture rooms and laboratories, and terminate in polarity receptacles, which are fused for ten amperes. Lanterns are supplied from large slip contact boxes, fused for sixty amperes. In the electro- and physical-chemistry

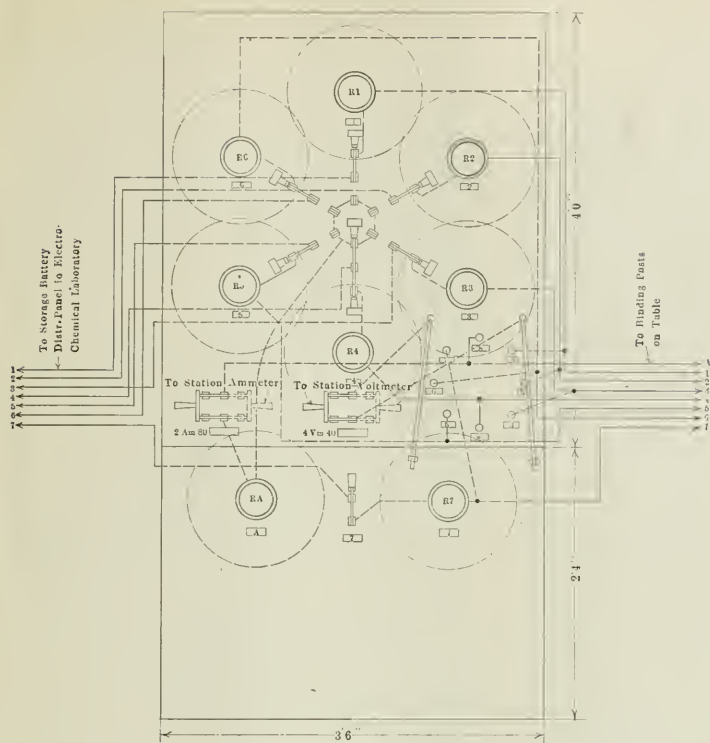


FIG. 7—SWITCHBOARD FOR ELECTROCHEMICAL LECTURE ROOM

laboratories, and the electrochemical lecture room, all three wires are brought to suitable wall and table switchboards, so that it is possible to obtain either 55 or 110-volt current, up to 25 amperes.

The storage batteries are located near the power room. Light is doubtless more provocative to sulphation of lead cells than is electrical abuse, consequently daylight has no access to the battery room, but ample ventilation has been provided. At present the installation consists of twenty-one 100-amperehour, lead cells, arranged in eight groups, to give four, eight, six, four, two,

eight, six and four volts, respectively. It will be noted that, with only one or two exceptions, any voltage from two to forty-two, can be obtained in steps of two volts. Each group of cells is wired to a two-pole, double-throw switch on the battery charging panels E and F in the motor room. These switches, when thrown down, connect the various units of the battery with the battery distribution board in the electrochemistry laboratory, and when up, to the charging mains. In order to avoid voltage fluctuations incidental to "floating the battery on the charging line," it is frequently necessary to charge certain units while the others are discharging. This has been made possible by ingenious interlocking single-pole switches, which throw simultaneously with the charging switches. These singlethrow switches merely complete the circuit for the charging current, across any units which may be discharging. It is obvious that were it possible for a single-pole switch to be closed while its companion double-pole double-throw switch is in the "charge" position, the net

result would be a short-circuited battery unit. A special spring interlocking device prevents this possibility by permitting the single-throw switch to close only when the double-throw is in the "discharge" position. In the charging circuit are rheostats, ammeter, voltmeter and circuit breaker, with both overload and reverse current release features. By throwing a double-pole, double-throw switch one can charge from the 55 or the 110-volt mains, as conditions require.

Close inspection of Fig. 2 will show the details of these switches, while Fig. 5 is a larger scale diagram of the wiring arrangement on panels E and F.

For distribution of storage battery energy, the positive ter-

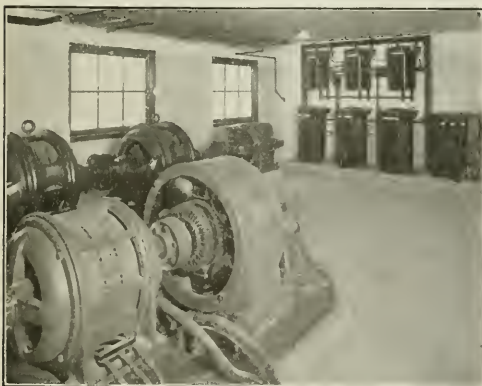


FIG. 8—GENERATOR FOR SINGLE-PHASE CURRENT

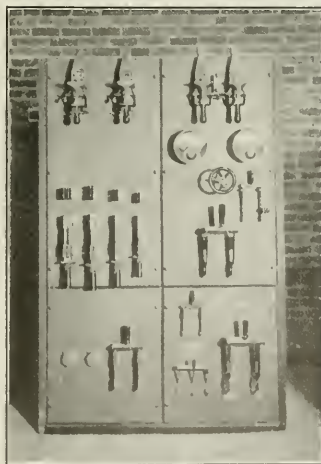


FIG. 9—CONTROL PANELS FOR HEAVY ALTERNATING AND DIRECT CURRENTS

terminal of group 1 is brought to the positive position on the panel in the electrochemical laboratory (Fig. 6). A common wire connects the negative of group 1 and the positive of group 2 to the second receptacle; a third, the negative of group 2 and the positive of group 3, to the third receptacle, and so on down to the last, which connects the negative of group 8 to the negative position on the distribution board. It will be seen that only nine sets of receptacles are required to handle the eight groups of cells.

From this distribution switch-board wires run to each working place in the electrochemistry laboratory, to lecture rooms, and to all laboratories throughout the building, and terminate in knife switches, with wing connecting lugs, mounted on small wall panels. These circuits are fused for 20 amperes. Connection is made between battery lines and distributing lines by means of flexible cords. Any voltage within the limit of the battery may be impressed on any circuit. This layout is shown in detail in Fig. 6.

In the electrochemistry and metallurgical lecture room is mounted a demonstration switchboard (Fig. 7) very similar to the one described by Bancroft,¹ ex-

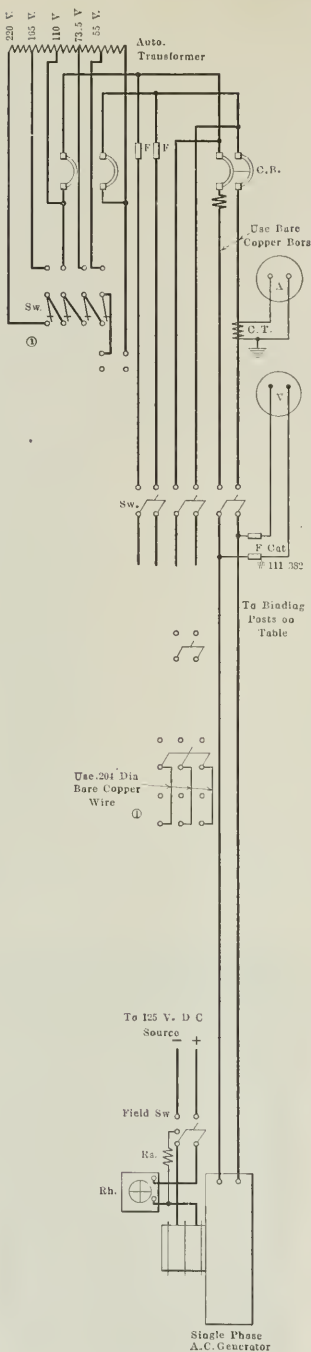


FIG. 10—WIRING FOR CONTROL PANEL IN METALLURGICAL LABORATORY

cept that we have 42 volts available, while he had 30. This board is fed direct from the charging panel, and is not dependent for its current upon flexible connections, which might be disarranged during a demonstration.

The lecture table has a double set of binding posts marked A, 1, 2, 3, 4, 5, 6 and 7, for tapping off the current controlled by this switchboard. Station type ammeter and voltmeter are mounted on the wall above the table for giving current indications on all possible combinations. Several plug connections are provided, set flush with the table top, giving 110-volt alternating current, or 55-110-volt direct current. A bank of rheostats controlling these latter circuits is mounted under the center of the table.

Power for heavy electrochemical and metallurgical operations is obtained from a 62½-kva., 60-cycle alternator, or from a 24-kw., 35-100-volt direct-current generator.

The alternator set (Fig. 8) comprises a 10-120-volt, 825-ampere, 60-cycle generator, with its 6-kw., 120-volt exciter, coupled direct to a 100-hp., 2200-volt, 1200-rpm., 3-phase synchronous motor. The motor is protected against overloads by maximum current, no voltage, and inverse time overload relays, operating the line oil switch. The first requirement of a plant furnishing power for experimental furnace operation is flexibility, owing to the varied characteristics of the many types of furnaces which are to be operated. With this in view, the machine and transformer have been so designed that it is possible to obtain a voltage range of from 0 to 250, in practically an infinite number of steps; and a current range of from 0 to 1500 amperes below about 40 volts, or from 0 to 62500/V amperes above 40 volts. If higher current values are desired for a short time they may be obtained within the ability of the machine to care for short-time overloads.

The voltage of the generator, normally 110, may be decreased to practically 0 or raised to 125 by means of a field rheostat mounted on the control panel in the metallurgical laboratory, Figs. 9 and 10. A field switch mounted below the rheostat makes it possible to cut off the power quickly without serious arcing across the line switch. The generator delivers its power to an auto-transformer mounted directly behind the control panel. Taps brought out from various windings of this transformer enable one to draw current at 55, 74, 110, 165 or 220 volts, when the generator is excited to 110 volts; or at proportionally lower voltages when excitation is lower. Transformer and leads are protected by two double-pole overload circuit breakers, one on the primary side set at 800 amperes, the other on the secondary to open at 1500 volts. Transformer taps are connected with the furnace leads through a series of fool-proof interlocking switches, which are so arranged that it is impossible to short-circuit any winding of the device. Furnace leads are connected to lugs on the front of the control board. A 500-ampere line extends to an electric welder in the rear of the metallurgical laboratory, and a 250-ampere line to the office of the assistant professor of physical chemistry. An ammeter and a voltmeter, both on the primary circuit, enable the operator to keep track of power consumption.

A 24-kw. motor generator set, driven by a 40-hp., 1200-rpm., 3-phase, 220-volt induction motor, has been provided for direct-current furnace operation. The installation of a separate unit for this purpose was deemed advisable, owing to the fact that classes in the metallurgical and electrochemical departments are scheduled in such a manner that two machines will at times be necessary to supply the demands. This machine is shown in the left foreground of Fig. 4, and is

1. Transactions of the American Electrochemical Society, 9, 333 (1906).

designed to deliver power at from 10 to 100 volts, with a current maximum of 1000 amperes. Since constant voltage is frequently desired for direct-current work, a special voltage regulator has been installed on panel J of the main switchboard which will automatically maintain any desired voltage from 25 to 80. The generator may be self excited, or excited from the synchronous converter. Hand regulation may be had when required.

The control panel for this machine is located on the main switchboard in the power room (panels I and J). On it are mounted motor-ammeter, generator-ammeter and voltmeter; field switch, voltage regulator, field rheostats, line switch and circuit breakers. In arc furnace operation it is necessary that the student whose duty it is to handle the switchboard be able to control or supervise the control of the electrode separation. Since in operating this machine this individual is at some distance from the furnace an electric hoisting and lowering device, controlled at the panel of this generator, has been designed to operate the electrodes. This device is driven by a $\frac{1}{2}$ -hp., three-phase motor, controlled by a three-pole, double-throw switch.

Cables for distributing power from this machine to furnaces are attached to lugs on the front of the switchboard in the metallurgy laboratory. Two 100-ampere lines run to the electrochemistry room, making it possible to carry on low-voltage electrolyses of high-current requirements in that laboratory.

Cincinnati, Ohio.

Is Not Gas Power Cheaper Than Water Power?

By H. G. H. Tarr

Some years ago the writer published an article in one of the mechanical journals the title and subject of which was almost identical to this.

The only recognition it received, so far as the writer knows, was a most cordial letter from the late George Westinghouse, who was ever alert for a new idea, however startling. He had investigated the Mond by-product system in England and indorsed in its entirety the premises and conclusions of the article.

There is a new condition now, and this country must of necessity do something not only to conserve her agricultural resources but strengthen her defenses. Curiously these are very closely allied; in fact, they are inseparable and alike dependent upon cheap power.

In view of this I am emboldened to risk again want of recognition by presenting here revised facts and figures that are not wholly new, and data of that which is being done in England and in continental Europe, in hopes that it may arrest the attention of either one of the masters of progress—Capital or the Government.

Everyone knows that without nitrate war would be impossible, and everyone knows equally well that nitrate is the life giver to all that grows. Therefore it is the one life sustainer, and the life destroyer.

We all know as well that there are two sources of supply of nitrate: Chili (for all that has been found on the surface of the earth aside from Chili is a negligible quantity) and the air we breathe. As the supply of the former is subject to more vicissitudes than Antonio's Argosy as described by Shylock, we, like the Germans, must of necessity fall back upon the air we breathe.

When the European war began the world was surprised to learn from shipping statistics the enormous imports of sodium nitrate from Chili into Germany. In addition to this they commandeered all that destined for fertilizer and purchased the output of the "from-the-air plants" of Norway. That was preparedness.

Notwithstanding this the war would now be at an end upon terms dictated by the Allies but for Germany's synthetic plants and processes; so it follows that as a life destroyer it is as essential to the life of a nation as a life-giver or a life-sustainer.

We therefore reach the conclusion that the production of nitrate from the air is a nation's only means of safety as well as prosperity, and as power is essential to this, the all important problem is cheap power.

Is it not possible that we imagine water to be the only very cheap power because we have grown up to think of it as such from the very days when we went swimming in the old mill dam and watched the big wheel go round? And is it not true that when we examine a modern water power plant and calculate its cost from land damages to thermal results we wonder if the old miller didn't take more toll from the grain than the law allowed. Else how did he support his family? However this may be, we fail to find many of the larger water power enterprises paying dividends. So it is possible that except under most favorable conditions power from coal may be cheaper than from water, thus the comparison will be interesting.

Let me first describe briefly the process by which it seems possible to attain this end, the by-products gas producer.

It is the invention of Dr. Ludwig Mond, F. R. S., and was first put into operation at the Brunner Mond Chemical Works in England. It will be remembered that all bituminous coal contains more or less nitrogen and upon the nitrogen content depends the value of the coal for this process. English coals have rather more than American, ours rarely going over 1.5, which is rather unusual.

The producer gasifies all of the coal, and the process extracts from the gas the nitrogen in the form of sulphate of ammonia. There is obtained from a net ton of coal about 140,000 ft. of gas having a heat value of 135 B.t.u. per cubic foot, and if the coal gasified has a nitrogen content of, say, 1.2, it gives about 70 lb. of sulphate of ammonia.

The coal is gasified at a comparatively low temperature to avoid the destruction of the ammonia, this low heat being maintained by introducing steam. From the producer the gas passes through a regenerator, so arranged that part of the heat of the gas and steam is transferred to the blast of air entering the producer. It is then delivered to a mechanical washer where the dust and soot is washed out and the gas further cooled.

After the gas has been washed the next step is the recovery of the ammonia contained in it, and for this purpose it goes to the acid tower, passing upward. Here it comes in contact with a descending spray of a weak solution of sulphuric acid with which it enters into combination, thus forming sulphate of ammonia. This solution of the sulphate of ammonia circulates again and again until it has attained a strength of 36 to 38 per cent at which it is drawn off and evaporated. The gas having now given up its ammonia is passed through another tower for final cleaning and cooling and is ready for use, unless it is to be used for power in a gas engine; then it passes through a tar extractor by which almost the last trace of tar is removed.

In making the comparison between water and gas power, we will consider the proposition of gas-fired steam boilers and the use of steam turbines. This seems to work out better than gas engines from every point of view, the most important being a much cheaper and more dependable installation. The coal economy of the gas engine may be a little higher, but if the by-products are worth as much as the coal costs why consider coal economy seriously?

For comparison it is perfectly fair to locate our gas plant directly at the mine and save all coal transportation. Water power must be where water flows so let us locate gas power where the coal is mined.

There are hundreds of coal mines as near Pittsburgh, Cleveland, Cincinnati, Columbus, Indianapolis, Omaha, Baltimore and many other great cities and centers of population, as we would expect to find any considerable water power. Aside from this in considering a nitrogen plant the transportation of the product is not a large tonnage, in a gas plant approximately 15 per cent that of coal. As there are no transmission lines in either case they are not considered.

The cost of the water plant is taken from the report of a reliable engineer on a plant erected in the West, and by comparison with the costs of several other large plants it seems fairly correct.

20,000-Hp. WATER POWER PLANT

Cost of 20,000-hp. water power plant in 1908 estimated at \$3,555,000. Assuming an increase in cost of 50 per cent. the same plant would cost now \$5,333,000.

Operating Cost per Year

Labor	\$60,000
5 per cent interest on \$5,333,000	266,500
Sinking fund	150,000
Repairs and depreciation	139,500
Taxes and insurance	40,000
Total operating cost	\$656,000

Income Water Power Plant

Considering a load factor of 85 per cent, an average of 17,000 hp. will be delivered every day in the year equal to 111,100,000 kw.-hr. per annum. Assuming for comparison that 1¢ kw.-hr. sells at 1¢, the total income per year would be.....\$1,111,000

Profit of Water Power Plant

Total income as calculated above.....	\$1,111,000
Total operating cost calculated above.....	656,000
Profit per annum.....	\$455,000
or 8.5 per cent on total investment of.....	\$5,333,000

20,000-Hp. STEAM POWER PLANT WITH MOND BY-PRODUCTS RECOVERY

In 1908 we calculated the cost of the gas plant at \$600,000. The present-day cost will be about 50 per cent higher, or.....\$900,000

The boiler plant would consist of 8000-hp. boilers for active service and 2000-hp. boilers for spare capacity, or a total of 10,000 boiler hp. Estimating the cost at \$30 per boiler horsepower, the boiler plant will cost erected.....\$300,000

The turbo-generator plant would consist of 20,000-hp. turbo generators for active service and 6000 hp. for spare, or a total of 26,000 hp. Estimating the cost at \$40 per horse-power the turbo-generator plant will cost erected.....\$1,040,000

The total investment of the steam plant, therefore, would be as follows:

Cost of coal lands, say.....	\$500,000
400-ton Mond by-product gas plant.....	900,000
20,000-hp. turbo-generator plant.....	1,040,000
Cranes.....	12,000
Switchboard.....	34,000
Boiler building.....	80,000
Generator building.....	50,000
Incidentals.....	244,000
Total investment.....	\$2,860,000

Operating Cost per Year

Labor	\$70,000
Interest, 5 per cent on \$2,860,000	118,000
Interest on coal lands cost of \$500,000 at 5 per cent.....	25,000
Sinking fund	100,000
Repairs and depreciation	130,000
Taxes and insurance	30,000
Coal, 149,000 tons (2¢ per horse-power hour) at \$1.50.....	224,000
Acid (1 ton per ton of sulphate) at \$12.....	63,000
Total operating cost	\$760,000

Income Steam Plant

Current at 1¢ per kilowatt-hour as before.....	\$1,111,000
Sulphate (70 lb. per ton of coal) at 3¢. per pound.....	312,900
Total income	\$1,433,900

Profit of Steam Plant

Total income as calculated before.....	\$1,433,900
Total operating cost calculated before.....	760,000
Profit per annum.....	\$673,900
or about 23 per cent on total investment of \$2,860,000.....	

From this it would appear that a by-product gas plant is more economical than a water power by about 14.5 per cent under the same conditions of load. etc.

These figures being approximately correct, the first question that will be asked is, "How near is it practicable, and how much is experimental." The answer is, "Entirely practicable and not at all experimental." Bear in mind we are speaking of a power plant to generate electricity for a nitrogen plant.

There were in operation in England ten years ago six of these plants aggregating 110,000 hp., varying in size from 10,000 to 25,000 hp., and ten or twelve smaller ones.

Brunner Mond's enormous chemical works are run entirely on by-product gas. In South Staffordshire there is a central plant distributing this gas over an area of 123 square miles and supplying heat and power to about 2000 industrial plants. There is a 12,000-hp. plant in Spain that uses its lean brown coal that is rich in nitrogen, however, and one in Buenos Aires. In France and Germany there were several before the war. Of how many now we have no knowledge.

In this country there has been only one built, which ran for several years with perfect uniformity both in quality and quantity of gas and sulphate of ammonia produced, but is now closed down for causes not at all attributable to the gas plant.

There are several reasons why we have not built more of them. Similarly, the first cost is too much per horse-power, when considered in combination with the gas engine, and heretofore only a combination with this form of motor has been considered; but it is the impression of the writer that the day of the by-product gas plant has now arrived as a power producer in competition with the even more expensive installation of an average water power.

Are American coals suitable for the by-product process? Some are and very many are not. As we have said, our coals are not as rich in nitrogen as the English, for in England they get from 90 to 100 lb. of sulphate of ammonia per ton from many, while 80 lb. would be a high result here. There are so many good coals here, however, that we need not despair of getting high results. The coals of Pennsylvania are not suitable, as no highly coking or caking coal is. Hocking Valley has been used in large quantities with excellent results. Southern Indiana has some coals that are excellent. Of all that have been tested for this purpose the best were from Kentucky—high in nitrogen while they burn freely and do not cake or coke in the producer. Aside from this any coal that has sufficient nitrogen content is suitable, and it is believed that present studies will develop a producer that will overcome this obstacle.

In the foregoing estimate we observe that we have consumed 149,000 tons of coal and produced (70 lb. per ton of coal) 522 tons of sulphate of ammonia.

A favorite mixture of fertilizer for cotton is 200 lb. acid phosphate, 85 lb. of kainit, and 100 to 150 lb. of nitrate of soda to the acre. The nitrate of soda can very well be, and is in many cases, replaced by sulphate of ammonia which furnishes 23 to 25 per cent of ammonia, whereas nitrate of soda has nitrate equivalent of about 19 per cent. If 100 lb. of sulphate are used in the mixture for an acre our imaginary plant would supply the ammonia for 10,400 acres of cotton every year. How much cotton or corn this would grow is beyond the writer, but would it not be most interesting and instructive to follow the thought and calculate how much cotton could be grown from the nitrogen burned up in the coal consumed for power in the state of Georgia, for instance? But—"that's another story."

R. D. Wood & Co.,
Philadelphia, Pa.

Notes and Experiments Pertaining to the Metallurgy of Zinc

By Edward Mackay Johnson

Supt., Eagle Picher Lead Co.

In this article and others that are to follow, the author proposes to discuss phases of zinc metallurgy that will be of interest alike to students of the subject and to experienced operators. For the former class of readers there will be introduced some discussions of an elementary nature, as well as items having only an indirect bearing on the improvement of the art. For those of experience there will be given the results of practical experiments on a large scale designed to fill some of the gaps left by more prominent writers on the subject. The entire discussion will be based on the author's practical experience and personal observation at a number of the zinc smelters in the United States, and is offered in the hope that it will both supplement and confirm previous publications.

While technically the metallurgy of zinc is at least no more difficult than that of the other common metals, it involves a mass of minute details that exert an influence on the ultimate recovery of the metal. These will be discussed in the following order:

I. Preparation and roasting of the ore, including a discussion of different types of charge fuel and methods of mixing.

II. The pottery; manufacture of retorts and condensers; experimental records and costs.

III. Furnaces; details of operation; furnace temperatures with many experimental data on firing.

IV. Spelter production from typical ores; sampling and analysis; treatment of retort residues.

As a rule zinc ore is received at the plant either in the form of concentrates or as lump ore. Generally the concentrates are in a suitable condition or size to go directly to the roaster. If the ore be received in the lump form, it is of course necessary to crush and size it. The size varies for different ores, and for the same ore at different plants, using a revolving screen of 5-mesh, No. 14 wire, 7-mesh, No. 16 wire, or 6-mesh, No. 16 wire. The stationary sloping piano-wire screen also is used.

The most important point, however, to bear in mind is to have ample screening capacity, so as to remove the finematerial as fast as it is crushed to pass the screen openings, thereby having as great a percentage of the ore as near the size of the screen opening as possible, and no more dust than can be avoided. The above point is well known but often neglected, both in designing the crushing and screening department and in the operation of the same.

FORMATION OF DUST IN RABBLING

The problems encountered in roasting, and the failure to overcome them, are due not only to insufficient knowledge of the requirements of a roaster to do good work, such as regulation of air, heat, rabbling, thickness of bed, and chemical reactions, but also to the mechanical construction of a roaster to accomplish these results. Take, for instance, the question of rabbling or stirring. There is no doubt that an ore should receive the proper amount of stirring or turning over to do good roasting; at the same time the operation can be overdone as shown by the results given in Tables I and II.

The main point brought out by these figures is that the ore may be stirred or rabbled by a certain mechanical rabble in such a way as to increase the percentage of fine material between the feed and discharge ends of a kiln. This not only increases the dust loss but

TABLE I

Screen test of a Typical Ore

Mesh	Stirred with Little Grinding Effect		Stirred with More of a Grinding Effect	
	Green	Roasted	Green	Roasted
On 10	29.0	13.4	11.0	9.7
On 20	19.6	20.9	25.0	21.6
On 30	11.5	17.1	16.2	12.6
On 40	7.3	10.5	9.2	8.0
On 50	5.6	8.0	7.5	6.2
On 60	0.4	1.0	0.7	1.3
On 80	12.7	15.6	13.4	15.0
Through 80	13.0	12.7	15.7	24.5
	99.1	99.2	99.7	98.9

TABLE II

Screen Test of Another Typical Ore Giving Same Comparison as in Table I

Mesh	Green		Roasted	
	Per Cent	Per Cent	Per Cent	Per Cent
On 10	3.13	11.25	5.63	7.13
On 20	15.62	20.00	23.13	16.94
On 30	17.50	15.63	14.37	11.88
On 40	13.13	9.38	10.63	7.50
On 60	9.38	8.75	7.00	5.64
On 80	20.00	20.00	17.50	12.75
Through 80	18.13	13.75	20.00	34.37
	97.49	98.76	98.26	97.21

makes it a little more difficult to obtain as good results in roasting.

REGULATION OF HEAT, AIR AND RABBLING

While the writer has had considerable experience in practical roasting, he feels incompetent to discuss intelligently the theoretical questions relating to heat, air and chemical reactions and will offer only a few practical suggestions.

Each type of roaster has to be practically regulated relative to the amount of heat and air necessary to do good roasting, and sufficient rabbling must be given the ore to expose every grain to the action of heat and air. This regulation also varies for different kinds of ores. In practical roasting it is well to consider three classes of ores which are often received at zinc works.

First Class.—Under this class would be placed what are called hard ores, such as Joplin, Wisconsin and some of the Western ores. These ores do not give up their zinc very readily, and require harder firing in the zinc furnace. As a rule they are low in iron and the sulphur is practically all combined with the zinc. The so-called "free" atom of sulphur is present to only a small extent. The ore, therefore, in the feed end of the kiln does not generate much heat by the combustion of this free atom of sulphur. For this reason, in roasting this class of ore, it is advisable to aid and force the process by the use of extraneous heat as much as possible, without in any way sintering the ore in the first stages of roasting, gradually increasing the heat toward the discharge end of the kiln.

Second Class.—Assume this ore to be concentrates carrying 10 per cent to 15 per cent of iron in the form of pyrites. Due to the combustion of the free atom of sulphur in the first stage of the operation considerable heat is generated. It is, therefore, at the feed end of the kiln that advantage must be taken of this fact to economize in the use of fuel. It is sometimes not necessary to introduce any extraneous heat before the middle of the kiln is reached, and then force the roasting as fast as possible by increasing the heat to the discharge end of the kiln. In either of the above cases it is well to retain a good heat in the kiln for about 20 ft. near the discharge end. The writer's experience has been that a certain percentage of the sulphur left in the roasted ore is nearly always in the form of sulphate. The fact should, therefore, be kept in mind that it is immaterial how the sulphates are formed, or how much the ore is rabbled, or how long it remains in the kiln; the sulphates will not be broken up if the necessary heat is not provided.

Third Class.—Under this class would be considered the dust from dry concentrating plants and slime from wet mills. This class of material is dreaded by the metallurgist, both in roasting and in the distillation of zinc, and he rarely attempts treating it alone but mixes it with concentrates or crushed lump ore before roasting.

Dust and slimes are not only objectionable due to their fineness, with consequent high dust loss, but they nearly always carry considerable lead, lime, etc., which add to the difficulties of roasting and distillation. It would be more satisfactory, at least metallurgically, if the dust and slimes could be converted directly into a pigment. This is done to a certain extent, but due either to the commercial difficulties or to the losses of silver and gold, only a part of such material is now handled in this manner.

EFFECT OF UNROASTED SULPHUR ON ZINC RECOVERY

In considering the sulphur left in the roasted zinc ore it is customary at the plants to determine what is termed "faulty" sulphur (which is that sulphur existing as sulphide and soluble sulphate) by determining the per cent of sulphur combined with the calcium and lead that may be present, and deducting the same from the total sulphur found. It is generally assumed by the metallurgist that the sulphur existing as "faulty" sulphur exerts the most deleterious effect upon the recovery of zinc; while the sulphur combined with the lime and lead in the form of sulphates is not broken up or liberated, and consequently does not affect the results to such a marked degree.

Just why and for what reason sulphur has such a bad effect upon the recovery of zinc; and whether the effect is due mainly to chemical reactions taking place in the retort, thereby retaining zinc in the form of oxide or sulphate, or whether it is due to poor condensation of the zinc vapor, remain unsettled questions. So far as the writer's experience goes, there is no way of firing the furnace to overcome the effect, and the old rule of one per cent of "faulty" sulphur retaining two per cent of zinc holds good.

The sulphide sulphur has at least another bad effect upon the recovery of zinc which is sometimes lost sight of, and that is the formation of matte, which is exceedingly corrosive in the retorts. The fireman, in order to save his retorts from butchering, does not carry the distillation as far as he might otherwise do, with a consequent loss of zinc in the residue. On the other hand, if the fireman or superintendent insists upon working off the furnace, a high retort loss ensues which causes a loss through the absorption of zinc.

CHARGE COAL

This material may be divided practically into four classes, as follows:

1. Soft or dead coal.
2. Arkansas slack; semi-anthracite.
3. Anthracite screening.
4. Coke or coke breeze.

The first and second classes are used principally at the plants in the natural-gas field, while the third class is almost exclusively used at the coal-field plants. A small proportion of coke is used at times at some of the plants in both fields.

Dead Coal.—This fuel comes from near the surface of the ground, and in a good many cases is simply the strippings of the mine. The best grade of this coal answers very well as charge fuel, but some of it is of a very inferior quality. Each car of coal should be inspected before it is unloaded and if there is any doubt about its value a proximate analysis should be made.

A determination of the ash can be quickly made and is one of the best indications of the grade of coal, aside from a physical examination.

The following analyses are fairly representative of dead coal as received at the plants.

	Moisture Per Cent	Volatile Matter Per Cent	Fixed Carbon Per Cent	Ash Per Cent	S Per Cent
No. 1	1.8	27.07	63.0	6.8	1.00
No. 2	3.0	23.0	60.0	7.5	0.87
No. 3	2.0	23.0	60.0	12.5	1.85
No. 4	5.0	24.2	62.0	7.5	0.79
No. 5	4.1	23.4	52.4	20.1	....

The dead coal as received at the works is too coarse to be mixed in the charge and has to be crushed to a suitable degree of fineness. This varies somewhat at the different plants but rarely exceeds $\frac{1}{2}$ -inch. As this is practically the only requirement regarding the size of this coal, the method of obtaining the same is simple. Of late years the hammer type of breaker has replaced the jaw type crusher or corrugated rolls at some of the plants and is giving satisfaction especially for wet coal.

Arkansas Slack.—This coal is received in the form of screenings from the mines of Arkansas. Previous to its introduction as a very suitable material for the reduction of zinc it was practically a waste product, and could be bought for \$0.25 per ton at the mines. As soon, however, as the plants commenced to compete for this coal the price immediately jumped up and has continued to increase until at the present time it is at least \$1.30 per ton at the mines. Even at this price it still continues to compete with dead coal. Arkansas slack is sometimes used alone and sometimes mixed with dead coal in varying proportions. The experience of the writer is that when Arkansas slack is used the retorts clean out better, especially when Colorado or Western ores are being treated. In the case of one such as Joplin concentrate a mixture of $\frac{3}{4}$ dead coal and $\frac{1}{4}$ coke works about as well; any possible slight gain in the use of Arkansas slack being offset by the increased cost of that fuel.

The following analyses were made on some cars of Arkansas slack being used at one of the zinc plants a number of years ago.

	Moisture Per Cent	Volatile Matter Per Cent	Fixed Carbon Per Cent	Ash Per Cent	S Per Cent
No. 1	2.1	18.7	64.8	14.4	2.3
No. 2	2.1	11.3	72.3	14.3	2.4
No. 3	7.3	8.7	73.1	10.9	1.1
No. 4	5.2	6.5	72.1	16.2	2.4
No. 5	6.4	11.8	68.1	13.6	1.5

The sulphur driven off with the volatile matter was not considered, which accounts for the analyses footing up a little too high.

Arkansas slack deteriorates very little if any upon standing, and is not inclined to fire when stored. The writer has known of one or two instances where a pile of Arkansas slack was on fire, but is inclined to think it was due to the fact that the cars in which it was shipped had not been thoroughly cleared of a previous shipment of bituminous coal. The use of Arkansas slack as a charge fuel has practically been restricted to the plants in the natural-gas field.

Anthracite Screenings.—This is the principal charge fuel now being used at the various zinc plants throughout the coal field east of the Mississippi River.

This material is similar to Arkansas slack, but is somewhat more satisfactory as a charge fuel. It is a little lower in ash and sulphur and a little higher in fixed carbon. It is obtained principally from the coal docks, and when received at the zinc works does not require any further preparation before being mixed

with the ore. By the use of anthracite screenings a little more charge can be handled, and the retorts will clean out better than with many of the other kinds of coal.

Coke.—This class of charge fuel has never become extensively used. It has found a greater application in the plants of the gas fields than in the coal field, the amount seldom exceeding 25 per cent of the total fuel used. It is usually mixed with dead coal, and for certain ores it is more satisfactory than dead coal alone. When coke is used the residue does not clean out of the retorts so well, and in general there is very little to be gained by its use unless it is obtained very cheap.

Percentage of Charge Coal to Ore.—This varies from about 40 per cent to 60 per cent, according to the kind of ore being smelted, and represents the ratio of the pounds of fuel used to the pounds of ore as charged to the furnace. In extreme cases the percentage of charge fuel may go a little below 40 per cent or a little above 60 per cent. The proportion of coal used to the ore charged is governed by the way the residues clean out of the retorts, and consequently by the analysis of the ore. There is one exception at least to this, and that is when the ore carries such a high percentage of zinc that the tonnage is somewhat limited by not being able to work the furnace off dry enough. The difference has to be made up with fuel, and in this particular case it is policy to use a cheap grade of material. The burden or weight of charge that the retorts will stand also enters into the above exception.

MIXING THE ORE AND COAL

So far as the recovery of zinc is concerned, the method of mixing the charge is immaterial, but it is very essential that an intimate mixture of the coal and ore be obtained. The methods of getting the ore and coal to the mixing room differ somewhat at the various smelters, according to the arrangement of the plant and the amount of money available for the construction.

One very satisfactory arrangement is to have overhead steel bins with hopper bottoms, constructed with cut-off chutes so that the ore may be drawn off into tram cars. In one particular instance the tram cars have been replaced with traveling crane buckets electrically driven and holding from 2 to 5 tons of ore.

There are two important points to be kept in mind when considering the handling of ore at a zinc plant, namely, the low tonnage and the dust loss. Due to the small tonnage treated it takes some time to pay for any expensive mechanical installation; and by the time it is paid for it has to be replaced. Therefore, unless a reduction in dust loss be accomplished, it is questionable whether such expensive installations pay. This question will be discussed a little later on.

Mixing.—The actual mixing of the coal and ore differs in some way at nearly every plant. One of the oldest methods, and one that is still being used at some plants, is the pit or "lay-down" system. Two adjacent pits are constructed into which alternate layers of roasted ore and coal are spread until a charge is made up. The pits may be large enough to handle the mixture for either a half or whole furnace, according to whether two charge cars are to be used or only one. The latter method gives the best results due to the fact that the poorest mix obtains at the beginning and end of the process of feeding out of the pits into the elevator. In the first method this factor would come into play four times as against twice in the latter. Due to the high cost of the method and the poor mix resulting, especially when two charge cars are used, the pit system has been replaced at a number of plants by the concrete-mixer into which the coal and ore in proper proportions are fed in successive batches.

Quantity of Water Necessary.—Owing to the different degrees of fineness of the various ores, and to the variable quantity of moisture contained in the coal, careful attention must be given to secure a mix of proper consistency, neither too wet nor too dry. If the mix is too wet the furnace charger can not charge as fast nor as well, and the excess moisture has the bad effect of cooling the retorts, which in extreme cases would cause them to crack. Again any cooling of the retorts delays the process of distillation and increases the consumption of firing fuel. On the other hand if the charge is too dry, the charger can not get as much charge into the retorts, and the dust loss will be a little higher.

Cost of Mixing.—Table III illustrates the cost of mixing at different plants in the natural gas field and coal field under both the pit and concrete-mixer systems. The table affords an opportunity to compare costs and to judge how far one may be justified in installing mechanical means for handling and mixing the charge.

TABLE III

Case No. 1

Natural Gas Field; Pit System; 4-Block Plant; 70 Tons Green Ore Per Day	
1 foreman at \$2 per day.....	\$2.00
7 men at \$1.75 per day.....	12.25
Total cost per day.....	\$14.25
Cost per ton green ore.....	0.204

Case No. 2

Natural Gas Field; Pit System; 5-Block Plant; 85 Tons Per Day	
1 foreman at \$2.25.....	\$2.25
4 transfer men at \$2.....	8.00
1 car man at \$2.....	2.00
1 car boy at \$1.50.....	1.50
1 box boy at \$1.25.....	1.25
Total cost per day.....	\$15.00
Cost per ton green ore.....	0.176

Case No. 3

Coal Field; Concrete Mixer; 5-Block Plant; 110 Tons Per Day	
1 foreman at \$3.....	\$3.00
6 men at \$2.....	12.00
1 box boy at \$1.25.....	1.25
Total cost per day.....	\$16.25
Cost per ton green ore.....	0.148

Case No. 4

Natural Gas Field; Pit System; 5-Block Plant; 88 Tons Per Day	
1 foreman at \$2.50.....	\$2.50
6 men at \$2.....	12.00
1 man at \$1.85.....	1.85
Total cost per day.....	\$16.35
Cost per ton green ore.....	0.188

Case No. 5

Coal Field; Pit System; 5 Block; 100 Tons Per Day	
1 foreman at \$2.75.....	\$2.75
2 men at \$2.15.....	4.30
10 men at \$2.....	20.00
Total cost per day.....	\$27.05
Cost per ton green ore.....	0.2705

In this case the ore had to be unloaded by the mix-room men direct from box cars, which saved 3c. per ton

Case No. 6

Natural Gas Field; Concrete Mixer; 7 Blocks; 125 Tons Per Day	
1 man at \$3.50.....	\$3.50
2 men at \$3.....	6.00
4 men at \$2.....	8.00
Total cost per day.....	\$17.50
Cost per ton green ore.....	0.14

For the sake of comparison take No. 4 as representative of the pit system, using neither concrete mixer, overhead bins, nor expensive mechanical arrangement for getting the ore to the mixer. Take also No. 3 with overhead bins costing say \$15,000. Take No. 6 with bins costing \$10,000 and electric traveling buckets from bins to mixer costing say \$5000.

The difference between the first case and either of the last two cases is 5c. per ton; or, on the basis of 100 tons per day, \$5 per day, or \$1825 per year. At this rate it would require nine years to pay for the installa-

tion, without figuring anything for interest on the investment.

Suppose we assume an investment of \$15,000 that will result in saving $\frac{1}{2}$ of 1 per cent of the tonnage as dust and that the plant is treating 100 tons of ore per day; $\frac{1}{2}$ of 1 per cent of 200,000 lb. equals 1000 lb. of ore per day. If this dust be valued at only \$20 per ton the saving would amount to \$10 per day, or \$3650 per year and at this rate $4\frac{1}{4}$ years would be required to pay for the installation.

ORE MIXES

Quite a number of the plants are required to treat various types of ores, all of which are different in analysis; and while these ores are mixed with a view of obtaining a better recovery of zinc, or of keeping the per cent of iron as low as possible, no plant, so far as the writer is aware, has succeeded in operating furnaces so as to produce an easily fusible slag in the retorts, as is claimed to be done in Europe. The cause of this difference in operation is probably to be found in two items.

1. Difference in the retorts used.
2. The ores change too frequently.

The first of these objections can, of course, be eliminated; but as seen from the following illustration the second is the most difficult to overcome.

We will assume, for example, that a zinc company has a head office in a certain city, to which important questions must be referred for settlement. Consider that this company retains an ore buyer in the Joplin district, one in the Western States taking care of Colorado, Utah, etc., and possibly another in Montana. Now any one of these men may at any time wire the head office to the effect that he can purchase so many tons of a certain ore on a certain basis. From the knowledge of the results already obtained on this or similar ores, as to recovery and treatment cost per ton, the head official can approximately figure the margin. If the company needs the ore or can advantageously store it, and if the transaction shows a favorable margin, he wires the representative to buy. While the metallurgist may be occasionally consulted, circumstances such as this usually force a continual change of ores upon him.

BAD EFFECT OF CHANGING ORES

There are several reasons why the frequent change of ores has a bad effect upon the operations. In the first place it requires about a week to get the mix properly adjusted, and the foremen accustomed to the change, even when these ores have been handled before. In the case of a new ore it often takes longer than a week. Again, whenever the ore is changed the retort loss usually runs higher for a few days, and if it is a very bad change, like going from a low-grade zinc ore that is high in lead, iron or lime, to a high-grade ore similar to Joplin, all of the retorts may have to be renewed before the loss again becomes normal. The experience of myself and others has been that in such cases it is best to reduce the ore and increase the fuel for two or three shifts to permit the removal of most of the material left in the retorts from the foul ore. Another reason why a change in ores has a bad effect is due to the fact that the retorts and condensers suitable for a high-grade ore are not so well adapted to the low-grade ores.

Although American companies have not been able to properly mix their ores with reference to the formation of an easily fusible slag, the custom prevails of mixing certain ores in order to obtain better results in general, even though the recovery be the same as the average recovery of the ores treated separately.

Take, for example, roasted Joplin sulphide, 60 per cent zinc, or carbonate or silicate ore containing about 35 per cent zinc. Assume that the tonnage of Joplin ore going to the furnace is restricted to a certain amount on account of working off the furnace, or due to the burden the retorts will stand. Assume the fuel to be ample. In such a case it would be better to cut down on the Joplin ore and reduce the fuel, replacing both with the silicate ore, thereby putting through a greater tonnage.

Another well-known case of mixing is where one ore low in iron, lead or lime, is mixed with an ore high in these elements. This mixture not only has the advantage of a possible better recovery and a moderate retort loss, but a grade of spelter can be produced containing iron and lead within the commercial limit. If one of these ores should require easy firing and the other hard firing it would be a question from the standpoint of recovery whether it would pay to mix them.

When dust or slimes are treated they are nearly always mixed with some suitable ore or concentrates previous to roasting. It will, therefore, be observed from the preceding remarks upon the change of ores and ore mixes that each plant must work out its own policy according to its particular conditions.

Henryetta, Okla.

A Comparison System for Determining and Standardizing the Grain Size of Annealed Brass

By Geo. A. Miller, Jr.

The proper anneal of brass for the purpose of drawing the metal or otherwise changing its shape by pressure, without melting it, is a very great factor determining the properties of the final product, and in the present-day high cost of tool steel it is important as greatly affecting the life of the tools used in this work. Metallographic testing of brass and copper has therefore come to the front with great strides in aiding to determine, along with the usual chemical analyses, whether or no the specifications are being followed in the preparation of the metal.

Nearly all brass and copper is today purchased according to chemical composition, and also in the cases where the foundry anneals the sheets or blocks of metal there is a specified grain size, at a given magnification, prescribed. These limits are fixed and photographs illustrating these grain sizes are usually attached to the specifications.

It appears, therefore, that the companies furnishing brass and copper to consumers at a specified anneal might do well to adopt a standard magnification and to adopt a standard set of grain sizes similar to those used in the device which is here illustrated. The consumer could then obtain from any producer of annealed brass or copper exactly the anneal he desires by merely specifying that the grain size should be of certain size. There would then be no difference between the metal which company A might furnish or company B. Much of the present trouble would then, I think, be done away with.

It has been found that the different companies which furnish this brass use different systems in determining the grain size. In some cases the skill of the operator as a guesser comes into play and he looks on the screen of the camera and guesses that the anneal of the metal is of such and such a grain size. It is true indeed that after long practice the operator might be able closely to approximate the correct size, but guesswork in a manufacturing company that buys or sells according to speci-

fications is usually costly to someone where accurate specifications are closely followed by the receiving company.

Then again there is the old system of counting the number of grains, across the field of vision, shown on the screen of the metalloscope. The number of grains are then divided into the area of the field covered by the objective. By a direct test of this system in the laboratory of perhaps the largest consumer of brass and copper in the United States, it was found that not one in five men counted the same on one sample of brass without changing it in any way. This can easily be accounted for by the fact that the boundaries of the grains are often indistinct, and in routine work, where many samples are to be examined, the polish and etch cannot be given the same care and attention that a very fine piece of research work might receive. Consequently, these grain boundaries are indistinct, and great care, which is not always possible, must be taken to trace each one out. This method was used for a long time, but finally it was decided that it was too slow and inaccurate.

A set of clear microphotographs were next made, and by counting the grains very carefully and averaging the counts of five men, standard grain sizes were given these photographs. The set consisted of the following sizes: 0.025 mm., 0.030 mm., 0.040 mm., 0.050 mm., 0.070 mm., 0.080 mm., 0.090 mm., 0.100 mm., 0.125 mm., 0.180 mm. These specimens were carefully prepared and photographed so that no mistake might be made in the counting. The sample to be examined was then placed in position on the machine, placed in focus, and the image was compared to the set of photographs.

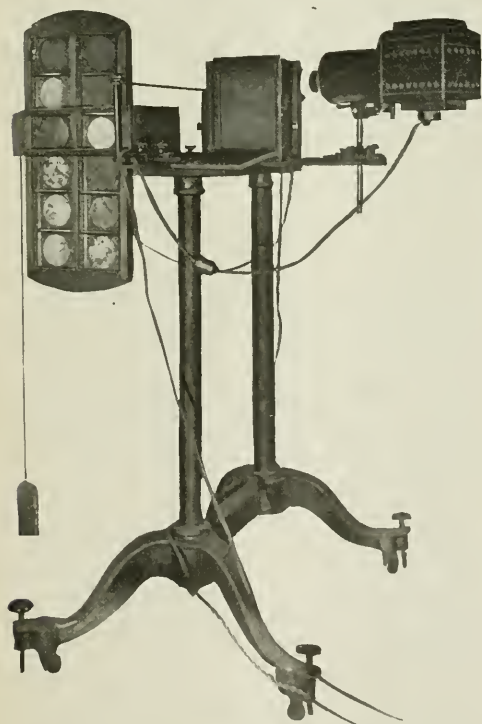


FIG. 1—FRONT VIEW OF DEVICE WITH TWO SLIDES IN POSITION

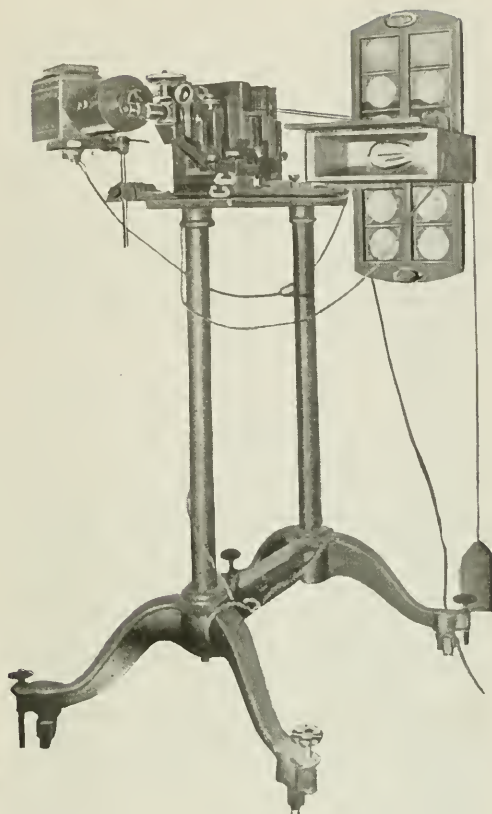


FIG. 2—SHOWING REAR OF DEVICE OPEN TO SHOW LIGHT

until the grain size was found. This system was much faster and very much more accurate, and the results obtained by different observers checked to a very close degree of accuracy.

This microphotograph system worked very well indeed and proved to be a great time saver, but some difficulty was encountered in comparing the image on the screen of the camera with the opaque photograph. Therefore, the idea was formed of producing as nearly as possible a condition similar to that of the screen of the camera and to have the grain size show up on the comparing screen as nearly as possible to the image of the camera.

Accordingly, lantern slides were made showing the various grain sizes and were placed in the frame, shown in the accompanying photographs constructed in such a manner that it could be moved up and down to show two slides, carrying photographs of grain sizes which differed by 0.010 mm., in position at the same time, whereby the relative size of the grains shown by the camera image was determined by approximating between the two slides. A half way, or 0.005, approximation was therefore easily obtainable. Very accurate results were obtained in this way, and the various men who operated the machine seldom varied in check reports by more than 0.005 mm., whereas by the old method errors of 0.020 mm. to 0.030 mm. were quite frequent.

These slides were illuminated by means of an electric lamp inclosed in the box (the rear view, Fig. 2, shows the box opened to show light). To further obtain the desired effect, the interior of this box was finished in orange shellac and a sheet of ground glass was placed between the lantern slides and the light. This was found to give very nearly the same condition as that shown on the screen of the camera. A counterweight held the frame at any desired height and the comparison was easily obtained between the slides and the image shown on the screen.

This comparison machine is quite compact. It was easily constructed in the carpenter shop and was easily attached to the frame of the metalloscope by a clamp similar to those used in holding the various parts of the machine on the base. Being constructed of light wood, it is not heavy and does not interfere with the normal operation of the machine.

Philadelphia, Pa.

A Glossary of Terms Used in the Rubber Industry

By Frederic Dannerth, Ph.D.

The rapid advance which has recently been made in the preparation of specifications for rubbergoods has brought with it a desire for more detailed information regarding the terms used in the rubber industry. Phrases such as "up-river fine Para," "Hevea rubber," and "fine Para rubber or its equivalent" are useless unless the buyer and the seller understand each other as to the meaning of the terms. With this in view the writer has taken some pains to obtain from the importers of crude rubber and from the manufacturers of rubbergoods a definite statement.

The terms in Group 1 refer principally to Hevea rubber; Group 2 to organic substitutes for rubber; Group 3 to factory terms; Group 4 to scientific terms; Group 5 to gums related to rubber; Group 6 to terms used in foreign countries.

The author hopes that this glossary will also be of considerable use to those called upon to testify in legal cases involving rubber or rubber products.

GROUP 1—TERMS REFERRING TO HEVEA RUBBER

1. *Fine Para Rubber*.—This material is obtained from the wild *Hevea brasiliensis* trees which are found along the Amazon and its tributaries in Brazil. It is put on the market in the form of "hams" (pelles or biscuits) resembling large watermelons. These hams lose about 20 per cent of their weight when they are washed and dried. They are called hams because of the peculiar smoke odor which clings to the rubber after the smoking (curing) operation. This rubber is characterized by its complete and uniform coagulation. In some cases the buyer will permit a maximum of one per cent of uncoagulated or partly coagulated rubber in the ham. This, however, is bad practice, as it is difficult to define 1 per cent.

The ball when cut shows the laminated structure of the ham, due to the fact that it is gradually built up by applying layer after layer of the rubber milk (latex) to the paddle. The layers can be readily separated. On fresh pelles which contain large percentages of water, the layers split off more readily than in the case of well dried specimens. Fresh shipments arriving at the port of New York usually contain not more than 20 per cent of water. Rubber which has been stored will lose more or less moisture according to the length of time it has been stored. If stored in a dry place for a long period, it will lose in weight, and because of the

absence of water it will command a higher price in the market. Hence contracts specify "old" or "new" rubber.

Fine Para rubber appears on the market in about twenty-five grades and varieties which vary in (1) tensile strength; (2) water content; (3) percentage of dirt. The grades are named after the several tributary rivers of the Amazon and after the port of shipment. Some of these grades (mentioned in the order of their quality) are: (1) Beni or Beni Bolivian; (2) Madeira; (3) Solimos, Javary, Jurua, Purus, Acre; (4) Mollendo, Angostura, Xingu; (5) Tapajos; (6) Matto Grosso, Caviana, Peruvian, Islands, Tocantins. The first three groups include the best grades. The Knapsack-Madeira grade is especially well adapted for the preparation of cements, and brings a fancy price because of its peculiar virtues. Caviana grade is sometimes made up to imitate the Knapsack-Madeira, and is therefore designated as Knapsack Caviana.

2. *Medium Para Rubber*.—This material prepared from the latex of *Hevea brasiliensis* is next to fine Para rubber in commercial value. It is recognized by the appearance of the ham when viewed in cross-section. Curds and globules of milk imperfectly coagulated are seen between the layers. These uncured spots and badly smoked spots may be only as large as a dime, or they may constitute as much as 25 to 50 per cent of the whole ham. The price is in consequence three or four cents below that of fine Para rubber.

3. *Coarse Para Rubber*.—This is *Hevea* scrap rubber prepared from the residue left in the latex cups. It includes latex which curdled before it could be smoked and made up into fine Para rubber, and occurs in commerce in two principal forms. "Up-river coarse Para" is distinguished from "Islands coarse Para" by being drier and harder, and the spheres or pelles are smaller. "Islands coarse Para" appears on the market in irregular balls about seven inches in diameter. This grade shrinks from 35 to 50 per cent, while "up-river coarse Para" loses 20 to 25 cent when it is washed and dried. Here again we find that brokers make a distinction between "old" and "new" lots.

Experience shows that Islands coarse Para deteriorates considerably when stored for twelve months. It contains as much as 6 per cent of resins in some cases while up-river fine Para rubber hardly ever contains more than 3 per cent of resins. At the present time considerable attention is being given by rubbergoods manufacturers to a determination of the resin content and the protein content of washed and dried rubbers, as it is now generally recognized that these constituents have a marked influence on the speed of vulcanization of the green rubber compound.

4. *Para Rubber*.—This term is used in the rubber market to include Up-river Fine Para Rubber; Islands Fine Para Rubber; Up-river Coarse Para Rubber; Islands Coarse Para Rubber; Cameta Rubber. All of these are prepared from the *Hevea* plant.

5. *Plantation Rubber*.—This term is used in the rubber market to include First latex crepe; Amber crepe; Brown crepe; Smoked sheets; Fine sheets, not smoked. Most of these are prepared from the *Hevea* plant.

6. *Hevea Rubber*.—It was proposed to use this term in specifications to avoid any discrimination between the product of the wild and the cultivated *Hevea brasiliensis* trees.

7. *Wild Rubber*.—That obtained from the Amazon Valley in Brazil and the forests of Africa whether it be from the *Hevea*, the *Castilloa*, *Hancornia*, *Manihot*, *Ficus*, *Landolphia*, *Funtumia* or any other rubber tree growing wild.

8. *Plantation Smoked Sheets*.—Rubber which has been hung in a "smoke house" after being coagulated with acetic acid. This method is known as "smoke-drying" to distinguish it from "air-drying." One of the earliest reliable brands put on the market was Highlands Sheet.

9. *Machine Smoked Sheets*.—These are prepared by subjecting thin layers of the rubber latex to the action of smoke in a machine. In this way the latex is coagulated in imitation of the original Brazilian "smoke cure."

10. *First Latex Crepe*.—The finest grade of plantation rubber from the *Hevea* trees in the Middle East. It is prepared by acid coagulation.

11. *Brown Crepe*.—This is filled with particles of bark so that it has to be washed before using. The bark is light and the loss seldom exceeds 5 per cent. This material is stronger than African Sud-kamerun Rubber.

12. *Crude Rubber*.—This term is generally applied to wild rubber which has not been washed and dried.

13. *Washed and Dried Rubber*.—Rubber from any source which has been freed from water and dirt by washing with water on a washing mill. Some rubber prepared on plantations and rubber for use in elastic bands is generally air-dried, but the bulk of all rubber used at the present day is vacuum-dried in specially designed apparatus.

14. *Refined or Broken-down Rubber*.—That which after washing and drying has been run on a warming mill until it is welded into a homogeneous plastic mass. In the case of Hard Para rubbers this is frequently performed sometime ahead of the actual mixing operation, as the operation of breaking down stiff rubber consumes time and retards the actual mixing operation.

15. *Deresinated Rubber*.—This term is preferably applied to washed and dried rubber containing not more than 3 per cent resins. The resins are determined by extraction with boiling acetone for five hours. This term is used specifically in describing Guayule rubber from which the major portion of the 20 per cent resin content is removed.

GROUP 2—TERMS REFERRING TO ORGANIC SUBSTITUTES FOR RUBBER

1. *Scrap Rubber*.—Worn out or discarded rubber-goods. It is purchased by reclaimers of rubber after it has been sorted. The character of the compounds originally used for making the rubber articles determines the grading of the scrap. Thus auto inner tubes are universally made of good rubber compounds and they sell in car-load lots for 26 cents per pound at a time when garden hose sells for 2 cents per lb., rubber heels, 3 cents; bicycle tires, 4 cents; airbrake hose, 5 cents; untrimmed arctic gum shoes, 6 cents; auto tire treads, 9 cents; and good red scrap 10 cents per pound.

2. *Reclaimed Rubber*.—Scrap rubber which has been freed from cotton or other textile fibers and put in a plastic condition. This may be accomplished by grinding up the rubber with oils; by heating the mixture of rubber and vegetable oil in an autoclave; by treating the rubber with caustic alkalis under pressure. The object in all cases being to remove as far as possible the sulfur which has been combined with the rubber.

3. *Alkali Reclaimed Rubber*.—Heating with dilute caustic alkalis is generally acknowledged to be the best known process for removing the sulfur from vulcanized rubber compounds. It is covered by a patent to Marks, No. 635,141, granted October, 1899.

4. *High-Grade Reclaimed Rubber*.—This term is preferably limited to reclaimed rubbers containing not less than 50 per cent of rubber substance. In view of the numerous sources from which the scrap rubber is obtained it is recommended that contracts for this material be accompanied by a statement showing specific gravity, non-volatile mineral matter, organic acetone soluble matter, free sulfur, total lead calculated as PbO. In the case of red reclaimed rubber the analysis should show the percentage of total antimony calculated as antimony pentasulfide. Most red stocks used in auto tires owe their color to red oxide of iron, and in recent years the red color of druggists' sundries has frequently been produced by means of organic dye lakes.

5. *Floating Reclaimed Rubber*.—This term is preferably limited to reclaimed rubber of specific gravity of 1.100 or less; free sulfur, not more than 0.05 per cent; rubber content, not less than 90.0 per cent; total sulfur, not more than 5.0 per cent.

6. *White Substitute*.—Elastic products prepared by the action of sulfur chloride on vegetable oils. If they contain more than 1.0 per cent of "non-volatile mineral matter" they are classed as adulterated. Specifications for this material should state the amount of "acetone-soluble matter."

7. *Brown Substitute*.—Elastic products prepared by the action of sulfur on vegetable oils. Specifications should state the amount of free sulfur and the amount of organic acetone-soluble matter.

8. *Rubber Resins*.—Substances occurring in all natural rubbers. They appear to be a form of oxidized rubber, soluble in acetone. Pontianak, Balata, Gutta percha and Chicle are especially rich and usually contain more than 50.0 per cent resinous matter.

9. *Pitch Hydrocarbon*.—This term is preferred to "mineral rubber" for the various pitch products prepared from asphalt, coal tar, petroleum, and stearin. It should be noted that petroleum pitch and the natural bitumens contain unsaturated compounds and these materials are therefore capable of absorbing a certain amount of sulphur. This is not equally true of coal tar pitch. Stearin pitch on the other hand contains a certain amount of saponifiable matter. The word "mineral rubber" although frequently used in the trade is misleading, and should be abandoned.

GROUP 3. FACTORY TERMS

1. *Green Stock*.—Washed and dried rubber which has been mixed with fillers and vulcanizing agents, but has not been vulcanized.

2. *Rubber Cement*.—A rubber compound which has been suspended in a volatile organic solvent such as benzene, benzol, or carbon tetrachloride. Some cements are made up with the vulcanizing agent and are sold in the form of a plastic mass for filling cracks in automobile tires. In other cases the cement is spread on a surface and the sulphur chloride is applied to the cement after the solvent has evaporated.

3. *Vulcanized Rubber*.—A rubber compound which has been subjected to the action of heat while under pressure in order to effect a chemical union of the sulphur with the rubber substance. The characteristics of vulcanized rubber are tensile strength and elasticity, both of which are absent in the green stock.

4. *Backing*.—This term is encountered in specifications for cotton rubber-lined fire hose. It is the thin sheet or layer of calendered rubber compound which is applied to the outside of the rubber tube, before the tube is pulled into the cotton jacket. The backing being of a softer compound, helps to bind the tube firmly to the jacket.

5. *Friction*.—A rubber compound applied to a cotton fabric in a thin layer by means of a friction calender. In this operation all the interstices of the fabric are filled with the rubber compound and the coated fabric so produced can be readily vulcanized to another piece similarly treated—or can be vulcanized to a surface of rubber compound. The word "friction" should not be used as a synonym for "adhesion."

6. *Skim Ply*.—A thin layer of rubber compound applied to cotton duck which has already been coated with "friction." This is done for the purpose of protecting the cotton fabric thoroughly (as in the case of rubber belting) or for the purpose of providing an especially rich compound to serve as a binder between two surfaces.

7. *Cushion*.—In automobile tires, a special ply of rubber compound placed between the breaker strip and the body of the tire. This serves to bind the tread of the tire firmly to the body of the tire (the layers of cotton duck).

8. *Bead*.—A solid, tough rim or edge extending around both edges of an auto tire and used for keeping the tire firmly in position after it has been sprung on the tire rim.

9. *Tread*.—That portion of an auto casing (automobile tire) which bears directly on the highway when the tire is placed on an automobile ready for use. The rubber compounds used for the tread are preferably tough and of great tensile strength, and firmly attached to the body of the tire.

GROUP 4. SCIENTIFIC TERMS

Rubber.—A hydrocarbon of the empirical formula $(C_{16}H_{16})_n$ contained in the latex of certain milk-bearing plants and separated from this by coagulation. When used in specifications, the word "rubber" is held to mean "washed and dried rubber," as it is found in rubber goods factories just previous to the compounding operation. It includes the natural resins, proteids, mineral matter and the rubber hydrocarbon itself. Rubber is characterized by its limited solubility in certain organic solvents; its ability to combine with sulphur in the proportion of approximately 100:7 to form a product of considerable tensile strength and elasticity; its specific gravity of less than 0.990. Rubber is also recognized by the formation of Nitrosites when treated with nitrous acid vapors.

Rubber Hydrocarbon.—This term is held to mean washed and dried rubber which has been freed from the natural rubber resins, proteids and mineral matter. It is contained in the latex of certain milk-bearing plants. In 1905 Professor Harries (University of Kiel) described it as a highly polymerized 1-5-dimethyl-cyclooctadien.

Synthetic Rubber.—Isoprene polymerized to a rubber-like substance having the same empirical formula as the natural rubber hydrocarbon.

GROUP 5. GUMS RELATED TO RUBBER

Balata.—A gum prepared by coagulation from the milk of *Mimusops globosa*. It is imported from Guiana and Venezuela in the form of blocks or sheets. The principal uses for the gum are in the manufacture of "balata belting" for power transmission and in the manufacture of dress shields.

Chicle.—A gum prepared by heat-coagulation from the milk of *Achras sapota*. This tree grows principally in Yucatan and the gum is exported in blocks from Tuxpam, Belize, Panama and other nearby ports. As imported into the United States it contains approximately 40 per cent water and the dry gum shows approxima-

tely 60 per cent resins. It is used exclusively for the manufacture of chewing gum, of which it forms about 25 per cent; the retail market price of chewing gum at this time is \$1.30 per pound.

Guttapercha.—A gum prepared from the milk of *Palaquium gutta*, a tree found in the Islands of the Malay Archipelago. It is frequently adulterated with resins, and in other cases balata is sold as gutta percha. The principal difference between these two gums lies in their physical properties so that it is difficult to distinguish between them by mere chemical tests. Extensive experience in handling gums is the only reliable way for arriving at the value of the crude material. Guttapercha is used by dentists for temporary fillings; for the manufacture of dress shields; for the manufacture of waterproof coverings for submarine cables.

Guayule.—A gum prepared from the herbaceous plant, *Parthenium argentatum*, found on the plateaus of Mexico. It is separated by macerating the stalks with warm water and subsequently floating off the agglomerated particles of gum. The dry gum shows about 20.0 per cent acetone-soluble matter (resins).

Pontianak.—A gum prepared from the milk of *Dyera costulata* and related species in Borneo and Sumatra. The latex is coagulated by means of kerosene together with acidic salts (such as alum). This gum is known in England as Jelutong, but here it is universally sold as Pontianak, the name of the port on the island of Borneo from which it is shipped. The dried gum contains about 75 per cent resins, a fact which makes it of especial value for the preparation of "friction" compounds in the manufacture of mechanical rubber goods.

Assam.—A gum prepared from *Ficus elastica* in Burma and India. Attempts have been made to cultivate these trees, but the difficulty lies in the fact that the milk coagulates so rapidly that it is impossible to collect large quantities of the milk for central coagulation.

Caucho Ball.—This gum is prepared from the *Castilloa elastica* and related species which grow in the Amazon Valley. This rubber is not coagulated by smoke. It occurs in commerce as "upper caucho ball" and "lower caucho ball," both of which are inferior to Hevea rubber. When washed and dried the "upper" loses 20 to 25 per cent and the "lower" loses from 37 to 40 per cent of its weight.

Castilloa Rubber.—This is obtained in Mexico from *Castilloa elastica*. It should not be confused with the Caucho Ball shipped from Brazil.

Manicoba Rubber.—This gum is prepared from *Manihot Glaziovii* and *M. dichotoma* and is shipped from the province of Ceara in Brazil. Since 1910 this rubber has become popular in America for the manufacture of high-grade products.

Mangabeira Rubber.—This gum is prepared from *Hancornia speciosa* and is shipped from Bahia and Pernambuco in Brazil.

African Rubber.—The principal "Africans" which are offered on the American market are in the order of their value: (1) Lopori, (2) Upper Congo, (3) Rio Nunez, (4) Conakry, (5) Massai, (6) Soudan, (7) Kamerun, (8) Benguela, (9) Accra. All these rubbers are obtained from various species of *Landolphia* and are therefore sometimes designated "vine rubbers." Accra rubber is also obtained from *Funtumia* and from *Clitandra*; while the rubber from the German colony of Sud Kamerun is obtained principally from *Funtumia* plants.

When purchasing these rubbers, the buyer judges them mostly by weight and general appearance. If they are dirty and full of sand, they will be obviously heavy. The loss on washing and drying these rubbers is considerable. Accra lumps may lose from 40 to 50 per cent

of their weight. On the other hand Upper Congo Balls may lose only 15 per cent of their weight. The price then varies from 25c. to 65c. (January, 1917).

GROUP 6. TERMS USED IN FOREIGN COUNTRIES

Plantation Para is the English term for plantation Hevea rubber.

Fine hard cure Para is the English term for up-river fina Para rubber.

India rubber: an obsolete term for rubber.

Caoutchouc: the French term for rubber.

Borracha: the Portuguese term for rubber.

Seringueira: the Brazilian name for the *Hevea* tree. Seringueiro: the Brazilian term for the man who gathers *Hevea* latex.

Latex (Brazilian): the milk juice of certain tropical plants which yield rubber.

Seringal: the forest where the *Hevea* trees grow.

Caucheiro (Brazilian): a collector of *castilloa* latex.

Chicleiro (Brazilian): a collector of chicle latex.

Urukuri nuts (Brazilian): the nuts obtained from the *Attalea excelsa* plant in Brazil and used there for "smoking" or coagulating the latex of *Hevea brasiliensis*.

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Electrolytic Equivalents of Gases

By Carl Hering

For calculating the amounts of gases set free by electrolysis by means of Faraday's law, the textbooks usually give the constants in terms of their weights, as that law is based on the chemical equivalents and these are in turn based on weights. Moreover for many purposes the weight of a gas (in effect, its mass) is the simplest and most rational way of specifying a given quantity of it, for when thus stated the quantity is independent of the pressure and temperature which become such disturbing factors whenever the quantity of a gas is stated in terms of its volume.

It often happens in practice, however, that one wants to know the quantities of electrolytic gases in terms of their volume, and with the usual electrochemical equivalents it is then necessary to make an additional calculation for which one requires additional physical constants; the textbooks often do not give these in their most convenient form, thereby involving still further calculations, and the reference books which give these data are not always readily available. Moreover Faraday's law, when stated physically instead of chemically, that is, when applied to the volumes of gases instead of to their chemical weights, becomes very much simpler for gases, as both the chemical weights and the densities then fall out of the calculation with the result that the physical constant which is involved then becomes the same for all gases (with some restrictions) hence no longer requires a table of values for the different gases. The purpose of this article is to give these constants in their simplest form and based on the best known fundamental data.

The latest, best and internationally accepted value of the fundamental electrochemical equivalent is that of silver, namely 0.00111800 gram per coulomb, and the internationally accepted value of the atomic weight of silver for 1917, is 107.88; both have been officially accepted by the Bureau of Standards.

From these two basic constants Faraday's law may be most conveniently formulated for calculations in practice, in the following terms:

The quantity of any element which undergoes electrolysis is *by weight* and for a change of valency of unity, equal to:

Atomic weight $\times$ 0.010363, in milligrams per coulomb.

Atomic weight $\times$ 0.037308, in grams per ampere-hour.

Atomic weight $\times$ 0.082250, in pounds per 1000 ampere-hours.

The reciprocals of these standard values are:

96.494 $\div$ atomic weight, in coulombs per milligram.

26.804 $\div$ atomic weight, in ampere-hours per gram.

12.158 $\div$ atomic weight, in ampere-hours per pound.

The physical meaning of these constants is that they would be the actual values for a hypothetical element having an atomic weight of exactly unity. As the atomic weight of hydrogen is 1.008 they represent that gas to within a little less than 1 per cent.

These apply to all the elements. They are, however, only for a change of valence of unity, hence for any other these constants of the first group must be divided by that change of valence, or those of the second group (the reciprocals) multiplied by it. It takes a certain definite quantity of electricity (96,494 coulombs) to make or break each chemical bond in electrolysis, and when there are two such bonds, that is when the valence is 2, it of course takes twice as much electricity, hence the quantity of material electrolyzed by a given quantity of electricity (as in the first group of the above formulas) will be half as great. Thus for oxygen gas for instance the above constants of the first group must be divided by 2, or those of the second multiplied by 2, as the change of valence for oxygen is almost always 2.

The writer is using the term "change of valence" instead of merely "valence" as used in most books, because the latter term alone may sometimes lead to very incorrect results, as it is not always the valence which an element has in a chemical compound which governs the electrolytic quantities, but it is always the *change* of valence during electrolysis which is the true governing factor, that is, the *difference* between the valences before and after electrolysis.

The valence of any element in its free, uncombined state is, of course, zero, because the term valence, in Faraday's law at least, means the number of bonds per atom which combine it with another element, and when not combined these bonds of course do not exist. Hence when in electrolysis an element is set free it means that it has changed its valence, from what it had in the compound, to zero; in that specific case therefore, and only in that case, is the "valence" numerically equal to the "change of valence" and it is only this particular case, and not the more general case, that the textbooks refer to when they give Faraday's law in terms of "valence" instead of more broadly and more correctly in terms of the "change of valence."

As an illustration, ferrous sulphate is oxidized (or adduced) at the anode to ferric sulphate; nothing is set free. The valence of the iron in the former is 2 and in the latter 3, the *change* of valence is therefore 1; the electrolytic oxidation has increased the valence by 1; oxidation always means an increase of valence or an addition to it, hence the proposed new and broader term "adduction"; the physically opposite to oxidation is a chemical reduction which always means a reduction of the valence. The quantitative electrochemical calculations of the amount of ferrous sulphate oxidized by a given current, must therefore be based on a change of valence of 1 and not on the actual valences 2 or 3, which latter would naturally give greatly incorrect results.

The increase and decrease of valences corresponding to oxidation and reduction necessarily mean that valences may be negative also, and that therefore a change from, say, -2 to zero (as in the setting free of

*See this journal, December 1, 1916, page 649.

oxygen) is an increase of valence. Bonds which represent a positive valence for one element are negative with respect to the other to which they bind it. The number of positive and negative valences in a compound must always add up to zero.

The above constants refer to the weights of the elements involved, and these weights per coulomb are different for each of the elements on account of their difference in atomic weights. When they are gases however, Faraday's law becomes much simpler if the amounts are stated by volume instead of by weight, as the atomic weights and the densities of the gases then drop out of the calculation, the physical constant then being (with certain restrictions) the same for all the gaseous elements. This is a consequence of a combination of Faraday's law with Avogadro's law, the latter being in effect that in their gaseous state a gram molecule of any element occupies the same volume, which for 0 deg. C. and 760 mm. is equal to 22.390 liters.

It is very necessary in this law to know how many atoms there are in a molecule of the particular element. But as the present article deals only with the six gaseous elements which are or may be set free electrolytically, at ordinary temperatures and pressures, namely bromine, chlorine, fluorine, hydrogen, nitrogen and oxygen, it will suffice for the present purposes that in all these elements the molecule is considered to have two atoms, that is, they are diatomic. But whether this is a mere theoretical conception or not, or whether it is correct or not, does not matter in what follows, as it can easily be shown from the above formulas and the densities of the gases that the simpler and more direct formulas given below give the correct results. Attention, however, is here called to the fact that this molecular structure of some of the gases applies only to the ordinary temperatures, because at very high temperatures chlorine, bromine, and probably fluorine, are said to change over to one atom per molecule, becoming monatomic.

With the above limitations, the combination of the laws of Faraday and Avogadro, and the above standard constants, give the following simple formulas applicable to the six elementary gases, bromine, chlorine, fluorine, hydrogen, nitrogen, and oxygen, at ordinary temperatures:

The quantities of any of these gases set free by electrolysis, at 0 deg. and 760 mm., are *by volume* and for a change of valence of unity, equal to:

0.11602 cubic centimeter per coulomb;

0.41767 liter per ampere-hour;

14.750 cubic feet per 1000 ampere-hours.

The reciprocals of these standard values are:

8.6193 coulombs per cubic centimeter;

2.3943 ampere-hours per liter;

67.798 ampere-hours per cubic foot.

As with the former groups, these values apply only for a change of valence of unity, and for any other those of the first group must be divided by that change of valence, or those of the second group (the reciprocals) multiplied by it. Thus 1000 ampere-hours will set free 1000×0.4177 liters of hydrogen whose change of valence in all ordinary cases is always 1; but only half as much oxygen will be set free because its change of valence in all ordinary cases is always 2.

The basic constant involved in the above may be more easily remembered by the fact that at about 50 deg. C. (accurately 53.82 deg.), that is, at about half way between the temperature of freezing and boiling water, or a little above blood heat, or about as hot as our hands can stand, the constant for these diatomic gases (at the normal pressure of 760 mm.) is equal to just 2 ampere-

hours per liter, hence a little more than two for room temperatures.

The equivalence between the quantity of electricity and the volume of the elements when in the form of gases or vapors, instead of their weights, may be termed the electrophysical equivalent as distinguished from the more usual electrochemical equivalents, as it is independent of the atomic weights. It may be said to be the fundamental or basic law, and that Faraday's law as usually stated is a deduction from it or a corollary. It applies strictly, however, only to perfect or ideal gases; it seems that the gaseous elements do not all behave like perfect gases, but the differences are slight, being apparently of the order of fractions of a per cent, hence can be neglected for all practical purposes.

Unusual cases might perhaps arise in which a gas in a higher combination is first reduced by the current to a lower valence and then set free. The above figures will, however, still give the correct results if the change of valence used is the total change from the original to the final (zero).

The above values are for 0 deg. and 760 mm. barometric pressure. The correction for any other atmospheric pressure would probably be negligibly small, but it is easily made by remembering that the volumes are inversely as the pressures, or roughly by percentages. Thus for 768 mm. the volume would be about 1 per cent less.

For the temperature correction it need only be remembered that the volume increases $1/273$ for each centigrade degree, or at the rate of 1 per cent for each 2.73 deg. C.; or for the Fahrenheit scale 1 per cent in volume for each 4.91 deg.

Philadelphia, Pa.

Mississippi Centennial Exposition.—Mississippi is to have a centennial exposition beginning Dec. 10, 1917, at Gulfport, on the Gulf of Mexico, and lasting about six months. A large force of men is at work on the foundations of seven of the buildings. These will be permanent, and include a coliseum to seat 5000 and the Mississippi State Building. Nearly all the other Southern States will have buildings. It will be the first large exposition to be held in the South for thirty years. The Government will have a \$750,000 exhibit.

American Dyestuff Industry Discussed at Textile Club Banquet.—The semi-annual banquet of the Textile Club was held at the Hotel Martinique on March 3. Several speeches were made on the progress of the manufacture of dyes in this country. Dr. B. C. Hesse spoke on "The Coal-Tar Industry and Preparedness," Dr. Thomas H. Norton spoke on "Is Germany's Primacy Assured?" and I. F. Stone spoke on "The American Dyestuff Industry." Dr. Charles H. Herty, Mr. William McComb and Dr. Herman A. Metz also delivered addresses. Dr. Hesse laid particular stress on the necessity of making our tariff really protective instead of leaving a loophole in it as it exists at present. Dr. Norton estimated that by 1920, at the present rate of expansion, we should be making the great bulk of the staple synthetic colors required by our industries. Mr. Stone said that the dyestuff industry here is on a permanent basis, for the reasons that we have all the primary coal-tar derivatives, such as benzol-naphthalene, etc., which are required, we have made a start at protecting the industry and the consumers realize the need of having our own industry. Besides this the manufacturers, owing to the abnormal conditions, have been able to make a good profit and to write off their plants and lay aside funds for research, increased capacity, etc., and are consequently in a strong financial position, and will be able to meet competition.

The Cementation of Iron and Steel

By Ernest Edgar Thum, E. M.

Assistant Professor of Metallurgy, University of Cincinnati.

Dr. Federico Giolitti, probably the greatest authority on cementation, has recently issued a very important book¹ on this subject, in which he analyzes and collects all the important work so far available. In the opening sections of the volume he summarizes the published data having a bearing on this matter which has appeared in the last sixty or seventy years, starting with the earliest work and the earliest theories. He then presents the work which has been done in his own laboratory during the last ten years, showing how his results have clarified many perplexing aspects of the situation. Lastly, he gives a very clear and full account of the various furnaces and methods employed in well equipped modern plants for the very important process of case hardening.

Dr. Giolitti's most excellent book suffers the inevitable defect of logical discontinuity which is bound to result in a compilation built upon a historical review of the development of praxis and theory. Such a method must result in considerable repetition of subject matter. Then, too, the discussion of the errors of the early experimenters which fills the opening sections presupposes familiarity with the most modern ideas of the subject upon the part of the reader. This, unfortunately, even but few metallurgists possess, nor will they acquire until they have read the book at least once. A second reading in this case is not particularly inviting, as unfortunately the English translation is much deficient in elegance—the style being very tiresome, involved and at times obscure.

"Cementation processes" include those which enrich the surface of wrought iron or low-carbon steel to various depths by the addition of cementite, (Fe_3C), that carbide which is responsible for the variation in the physical properties of soft irons and hard steels. The method consists of heating a carbonaceous substance in close contact with the iron to be carburized in a suitable container. From the iron-carbon equilibrium diagram it is evident that A_{c} (690 deg. +) is the minimum temperature at which true cementation can proceed; graphitic carbon will diffuse into iron at lower temperatures than this by reason of the forces due to the difference in concentration, and if it does combine with the iron the carbide produced cannot enter into solid solution until A_{c} is exceeded. Otherwise the properties of a more highly carburized true steel are lacking—the added cementite does not form increasingly large masses of pearlite, but remains as a fine meshwork of free crystals where it was formed. If 690 deg. C. is the minimum temperature for cementation, as a maximum limit the steel must be kept from "burning" during the carbonizing process—that is to say, below the point of incipient fusion of the austenite of the carburized muff. The rate of carbon absorption of liquid austenite is enormously higher than that of the solid solution, and the result will be a zone so high in carbon as to be a true cast iron. In short, true cementation proceeds only at temperatures and carbon concentrations bounded by the area where austenite (the solid solution of gamma iron and iron carbide) is stable, as delineated in the iron-carbon equilibrium diagram.

Total Carburization for Blister Steel

Apparently, the most obvious variation in cemented metal is the depth to which the carburization extends.

¹The Cementation of Iron and Steel, by Dr. Federico Giolitti, Professor in the Royal Polytechnic of Turin. Translated from the Italian by Joseph W. Richards and Charles A. Rouiller. Copyright 1914. New York: McGraw-Hill Book Co., 1915.

On this basis has grown a distinction between "total" cementation, where the piece is intended to be wholly transformed into a high carbon steel, and "partial" cementation, where the process is frankly limited to the production of a thin, hard case overlying the original low carbon tough material. As a matter of fact, the term "total" cementation is a misnomer, inasmuch as the process is seldom if ever continued to a time when there is a considerable increase in the carbonization at the very axis of the metal. The reason for this is evident upon reflection. The transference of carbon from without to within is caused by diffusion forces set up by the difference of carbon concentration at these points. We might expect that after a considerable time approximate equilibrium could be attained at the exterior of the piece, but that a continually decreasing carbon content would attend the deepest regions. When equilibrium at the center is approached, the difference in carbon concentration, edge to center, is so small and the consequent rate of diffusion so slow that the time necessary for total cementation of even small bars would be so great as to be absolutely prohibitive.

Deeply cemented bars are often forged directly into springs; or, after faggoting and rolling, into cutlery;

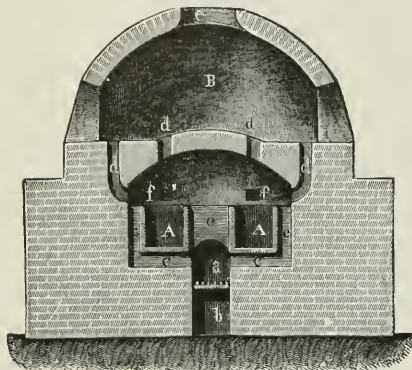


FIG. 1—CROSS SECTION OF CEMENTATION FURNACE

but preferably are first melted in crucibles to equalize their carbon content. Indeed, total cementation was the main source of steel up to Bessemer's discovery, and to-day survives as the producer of the highest grade of carbon-steel tools. The methods and furnaces used are exactly the same to-day as when the industry flourished a century ago, innumerable variations in practice having been tried and discarded meanwhile.

Fig. 1 (Fig. 73 from Giolitti) shows a cross section of the furnace used for total carburization. A pair of tight rectangular boxes of refractory brick some three by three feet in cross section and eight to fifteen feet long are built on either side of a long fireplace and enclosed in a massive masonry furnace-setting. Special provisions for uniform heating are made, such as a series of flues for the flames to play on all sides of the box and a double arched dome over the laboratory. Flat bars of the purest wrought iron are packed into these boxes, each bar entirely surrounded by a layer of crushed charcoal at least three-quarters of an inch thick, and the loaded box sealed by a layer of wheelswarf. When all is ready, coal fires bring the temperature of the furnace up to 1100 deg. C. in the course of two days, at which temperature it is kept as nearly constant and uniform as skill will permit until such a

time as the fracture of a "spy" withdrawn from the box indicates that the cementation has proceeded sufficiently. This requires a matter of from seven to eleven days, varying as the furnace conditions, cement in use, and the desired percentage of carbon. Cooling to a temperature low enough to enter the furnace setting and unloading it requires a matter of another week. The surface of the bars has now lost its metallic appearance and has acquired a dull brown, blistered surface. Each bar of this "blister steel" is then broken and classified according to its mean carbon content, as judged by the appearance of the fracture, when it is melted in the crucible, rolled or forged.

It is claimed that crucible steel made in this manner is superior to any other modern ferrous product. This, if true, is possibly due to the fact that the purity of the superlative wrought iron used in the cementation boxes is in no way vitiated by the subsequent process—indeed, the fusion serves to eliminate the remnants of mechanically entrapped slag. The cementation material regarded as the surest and best for this process is the result of centuries of experience with hundreds of mixtures and is simply crushed charcoal (2 to 15 mm.). The mixture of other solids into the cement serves no useful purpose whatever, for it is liable to add something as an impurity to the finished product. The result of melting cemented bars in the crucible is a high-carbon steel lower in silicon and manganese than that attainable in other processes without running the danger of oxidized and brittle products. Lately, the difficulty of getting a properly "killed" crucible fusion has led to the use of ferro-alloy deoxidizers which may increase the silicon or manganese content up to a point where such crucible steel is hard to distinguish either chemically or mechanically from a well-made electric furnace product.

The early observed fact that low-carbon steel bars do not blister in the cementation furnace while wrought-iron bars show this surface defect makes it appear likely that the slag is responsible for the occurrence of the blisters, inasmuch as the presence of particles of slag in the wrought iron is the prime difference in constitution of these two materials. In 1864 Percy proposed the most probable explanation: that the slag, consisting of basic ferrous silicates, was decomposed or reduced by the carburizing agent with the local production of a larger quantity of gas than could diffuse readily, the excess of which broke through the hot plastic metal and produced the characteristic markings.

Partial Carburization of Machine Parts

An enormous amount of experimental work has been done in an effort to elucidate thoroughly the mechanism of the carbonizing reactions which go forward during cementation, leading to various theories backed by as many ardent supporters. The whole matter has been reviewed and clarified by the experimental work conducted in Dr. Giolitti's laboratory, now summarized in his recent volume. This work would have been of minor practical importance were it not applicable to the process of

"partial" cementation. Though the manufacture of blister steel may be on the decline due to the sharp competition of high-grade electric furnace products, the advances in machine design call for an increasingly large number of parts which are hard enough to resist wear or abrasion, and yet tough enough to withstand shock and "fatigue." In all steels except some very expensive alloys, it is well known that a high hardness numeral is had at the expense of ductility, but the combination of these desirable but mutually contradictory qualities may happily be had by transforming the outer surface of a tough low-carbon piece into a hard high-carbon steel. Again, case hardening operations are the favorite method of producing cheap metallic pieces for taking a high polish. Or, lastly, the ends of such articles as axles may be carburized for bearings, while the rest of the bar can be entirely protected from the action of the cement.

The methods for this most important operation are various, depending first of all upon the cement used, whether solid, liquid, gaseous, or some combination of these three. As a matter of fact, a large percentage of the case-carburizing is done in a manner very similar to that of "total" cementation described above; that is, by packing the pieces in crushed charcoal in closed metallic boxes and then heating the box and contents. The size of heating furnace naturally varies with the shape and size of the metallic articles to be treated and the fuel used, and may range from the large coal-fired setting shown in cross section in Fig. 2 (Fig. 79 of Giolitti's book) to the small gas or oil-fired muffle type of Fig. 3 (Fig. 97 of Giolitti's book). In any case, it should conform to these general requirements: At the start of operations it should be capable of quick and uniform heating up to 1200 deg. C. During cementation the temperature at all points of the carburizing box or muffle should be held constant and uniform at any temperature between 850 deg. and 1100 deg. C., at the option of the operator, with a tolerance of from ten to thirty degrees. This requirement demands a tight

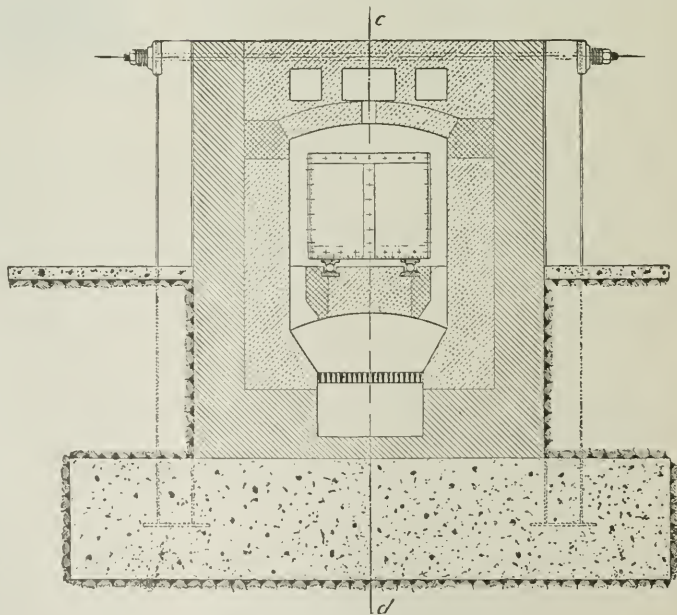


FIG. 2—CROSS SECTION OF LARGE COAL-FIRED FURNACE FOR CEMENTATION IN BOXES

setting, with heat-insulated charging doors of the lift type which can be clamped shut, and almost excludes the use of intermittent coal-fired grates. In order that the muffle or box containing the metallic pieces and the cement may not be rapidly destroyed, a neutral or reducing atmosphere should be maintained. Peep holes and pyrometer openings must be provided. Rollers, balls, or even cars, are provided to expedite the entrance and removal of the larger carburizing boxes, while economy of fuel and furnace maintenance demands continuous operation. The boxes themselves should have a tight cover which can be luted shut, and be as small as is consistent with the requirement that it must allow at least one inch of carburizer on all sides of the pieces. As will be seen, it is always necessary to pay particular attention to obtaining a close contact between solid carburizers and the metal.

Of the many kinds of carbonaceous materials used as cements, we will confine our attention at the outset to crushed wood charcoal, remembering that the mechanism of the action during "partial" or "total" cementation is identical, the sole difference being the amount of carbon absorbed by the metal—therefore a quantitative variation only.

The Diffusion of Carbon Into Iron

A superficial survey of the conditions existing in the cementation box would indicate that the carburizing action could be most readily explained by supposing that the carbon of the cement (charcoal being nearly pure carbon) merely diffuses as such into the carbon-poor iron. Doubt is thrown upon this view when it is learned that charcoal, as a cement, is rapidly "exhausted"; that is to say, its efficiency is continuously impaired upon re-use. The temperature of the process has by no means been high enough to graphitize or otherwise change the physical state of any considerable percentage of the charcoal carbon, and the view has been repeatedly advanced² that "solid carbon outside of a fragment of steel cannot penetrate into it without the intervention of a gaseous vehicle." However, Roberts-Austin³ heated in a vacuum previously ignited electrolytic iron in contact with diamond and obtained carburization. Giolitti (text, page 119) shows that the discrepancy in view is due to the fact that *actual physical contact* of the iron and the carbon is the prime requisite of solid diffusion. When this requirement is fulfilled, a three and one-half hour cementation in pulverized carbon at 1000 deg. C. will increase the pearlitic areas very slightly to a depth of 0.15 mm., while any portion more than this fraction of a millimeter distant from a carbon contact will be absolutely unaltered. In the practice of cementation when working with granular material ranging from two to fifteen millimeters in size, the continuous, deep zone of much higher carbon content resulting from a three and one-half hour cementation at 1000 deg. C. must evidently be due to some other cause than direct diffusion of solid carbon.

The first researches on the mechanism of cementation were undertaken to demonstrate that volatile alkaline cyanides were the true cause of the process, acting as carriers of the carbon into the iron. The earlier investigators thought that the alkaline ash of the charcoal reacted with the nitrogen of the air occluded in the pores of the charcoal, together with that remaining in the cementation box, forming the volatile cyanide required by their hypothesis. The "exhaustion" of the cement could then be ascribed to the volatilization of the alkalis in the charcoal ash.

It is unquestioned that the cyanogen radical has an intense carburizing action on steels at high tempera-

tures, but the amount of it existing in the ordinary cementation box packed with wood charcoal approaches zero—is so small as to escape detection by analytical methods. It has also been shown⁴ that charcoal which had previously been heated with chlorine gas to the elimination of the last traces of alkalis could be used as a cement in a nitrogen-free atmosphere, and give precisely the same results as were ascribed to the action of the cyanides.

Further, Giolitti (text, page 121) shows that a four-hour cementation at 1000 deg. C. with alkali-free charcoal in an atmosphere of pure nitrogen would produce a case containing a slight increase of pearlitic area at the edge—gaining about 0.20 per cent carbon at this point—the carburized zone decreasing in carbon content at a uniform rate to a depth of 1.8 mm., the maximum penetration of the carbon. This action appears to rest upon the equilibrium conditions of the little-studied system (N:C:CN: Austenite). In the case of carburization with charcoal, its effect is certainly very small. In a similar manner it has been shown that any hydrocarbons which may remain undecomposed in the

⁴Charpy, VI. Revue de Metallurgie, 505 (May, 1909).

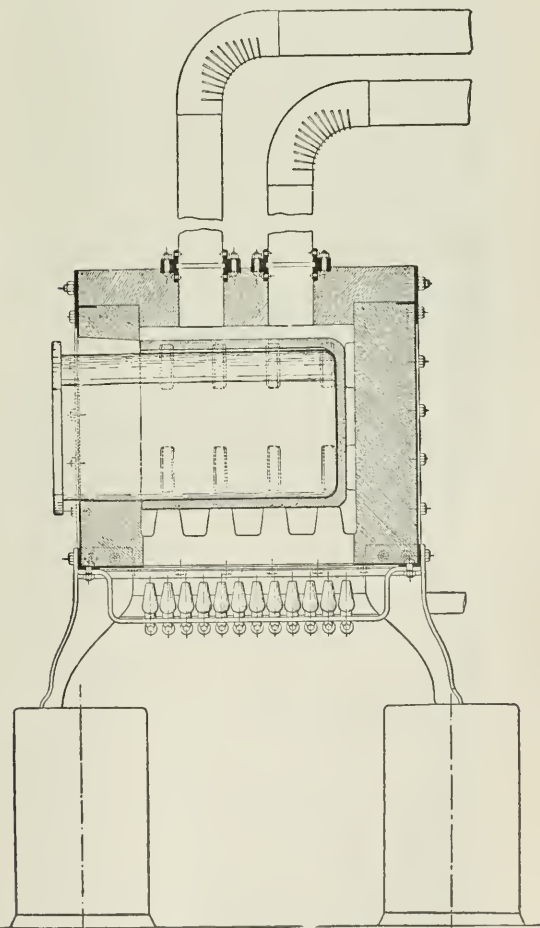


FIG. 3—LONGITUDINAL SECTION OF GAS-BURNING MUFFLE FOR CEMENTATION IN BOXES

²Charpy and Bonnet, CL Comptes Rendus 173 (Jan. 17, 1910).

³1890, I; Journal of the Iron and Steel Institute, 81.

charcoal have a negligible or at least a very small part in the cementation.

Carbon Monoxide the Vehicle of Carbonization

The remaining possibility proves to be the most active carburizer, namely, interaction between the oxygen of the occluded and entrapped air with the incandescent carbon. At the temperature of ordinary cementation (over 1000 deg. C.), the reaction $C + CO_2 \rightleftharpoons 2CO$ produces a gas with a very low percentage of carbon dioxide. This gas (particularly carbon monoxide) easily and rapidly diffuses into and reacts with the hot iron, forming iron carbide, which is immediately absorbed into the solid solution austenite. The reaction is $2CO + 3Fe \rightleftharpoons Fe_3C + CO_2$. The dioxide formed at this point diffuses outwards to a region of lower concentration more rapidly than inwards, while the monoxide diffusing inward will form more carbide on its way toward the center of the piece of metal, if demanded by the state of the system Austenite:CO:CO₂ existing at that particular locality. The carbon dioxide escaping from the steel is immediately regenerated by the excess of hot carbon to a condition represented by the equilibrium of the system C:CO:CO₂.

It is clearly seen that carburization will cease when the relative concentration of the gases in the packing, represented by C:CO:CO₂, equals that existing in the steel, which is represented by Austenite:CO:CO₂, for at that time diffusion of the carburizing gases will halt simply because of lack of head. As a matter of fact, the maximum carbon concentration in a case-hardened article never reaches the theoretical amount thus called for, simply because the process is interrupted long before equilibrium can be established.

It is also apparent that the isobars of the two systems are identical, Fig. 4 (reproduced from Hofman's General Metallurgy, Fig. 184), and that the maximum concentration of the carbon attainable by the use of charcoal as a cement is by no means necessarily equal to that of saturated austenite at that temperature, as defined by the iron-carbon equilibrium diagram.

Solid Cements

Of all the solid cementing materials, wood charcoal is the best, because, first, it is pure, and therefore maintains the purity of the product; and second, it is of simple composition, being practically carbon only, and therefore the carburizing reactions are not complicated by variable and unknown factors. This allows its use

with certainty of control; the results can be predicted with considerable accuracy. The greatest disadvantages are the slow speed of the cement and the phenomenon of "exhaustion," both of which now seem to be due to the limited amount of carbon monoxide formed in the box. Either the expulsion of occluded air, the covering of carbon granules by fusible, tenuous salts of the ash, or a slight change in the state of the carbon, would slow down the speed of the reactions ($C + CO_2 \rightleftharpoons 2CO$; $2CO + 3Fe \rightleftharpoons Fe_3C + CO_2$), which correspondingly diminishes the rate of carburization. The ordinary cementation time and temperature for "partial" carbonization—one or two hours at 1000 deg. C.—will furnish cemented zones less than 1 mm. thick with a low maximum carbon content. The maximum concentration of carbon at the external surface, the depth of the case and its uniformity will increase with the time the piece is maintained at elevated temperatures up to about 1.8 per cent attained in the practice of "total" cementation. In every instance, the percentage of carbon decreases without discontinuity from the edge to the lower carbon core at the center of the metal.

In order to increase the speed of the operation, it is necessary to add one-third to one-half unused charcoal at every packing, or, better, to mix into the charcoal in the first place some 40 per cent of powdered BaCO₃ (witherite). The latter procedure (recommended by Caron in 1861) is especially valuable in increasing the efficacy of the cement by bringing a large amount of gas to the cementation chamber; thus $BaCO_3 \rightleftharpoons BaO + CO_2$; $CO_2 + C \rightleftharpoons 2CO$. The first reaction goes to the left at lower temperatures—CO₂ being rapidly absorbed upon exposure to the air. Such a combination has the added advantage, therefore, of being inexhaustible; it is largely used today, and all things considered, is the best solid cement for "partial" cementation.

Caron's cement is capable of close control and of giving wide range of effects. The characteristics of the cemented zone are exactly the same as for wood charcoal alone, especially in that the distribution of the carbon diminishes continuously from a maximum at the superficies to the unaffected core; indeed, this is the characteristic of all cements whose specific action is primarily due to the presence of carbon monoxide. The speed of the operation varies as the percentage of admixed witherite and the speed of heating the carburizing box up to working temperature; both factors cause the speed of evolution of carbon dioxide to change. The maximum carburization attained in industrial practice will vary between 0.7 per cent for thin (2 mm.) zones formed at 900 deg. C. up to 1.3 per cent for thicker zones formed at 1100 deg. C.

At the best, Caron's cement suffers the disadvantage of all solid cements used in separate packing boxes, which is that the results cannot be predicted with a precision greater than about 70 per cent. This is due primarily to the variations in the rate of heating, caused by differences in the form and dimensions of the furnace, cementation box, and metallic articles; in the arrangement of the pieces in the box; and lastly in the low heat conductivity of the more or less finely ground cement itself. Again, the relative porosity of the charge affects the freedom with which the carbon monoxide gas circulates from place to place. Consequently, the published data regarding the relations between time, temperature, depth, and carbon concentration are at wide variance; especially so because in most cases the time of cementation is given from the time the outside of the box reaches the desired temperature. In practice, control of the process is best maintained by withdrawing and examining a hooked "spy" through the box covers when the process is

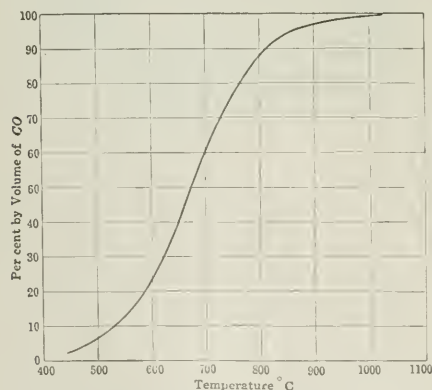


FIG. 4—EQUILIBRIUM CURVE FOR CO₂ AND CO WITH C AT DIFFERENT TEMPERATURES

judged to be two-thirds completed, at which time a closer estimate of the necessary additional time may be made.

Innumerable preparations have been recommended and are on the market for use as solid cements, but "there are only some *types of simple cements*, at present well known, whose efficacy is a *maximum* from all points of view, and the addition of other ingredients to these typical cements in *no wise increases their efficacy*" (Giolitti, text, page 261). The standard slow cement is Caron's mixture of barium carbonate and charcoal. This may be classed as a "slow" or "gradual" cement, and requires considerable time to produce its deep-seated carbonizations. "Rapid" cements are made of various mixtures of sawdust, wood charcoal, bone charcoal, leather, bone, lampblack, tar and heavy hydrocarbons, alkaline and alkaline earth carbonates and cyanides, ferro- and ferri-cyanides; together with homeopathic proportions of numberless other substances, all more or less inert.

Such compounds act by virtue of the large quantity of hydrocarbons or cyanides which are evolved; they exhaust rapidly, give very irregular and non-uniform carbon penetrations with a rapid discontinuous rise from the non-cemented core to thin, excessively high-carbon concentrations at the outside. The variable quantities of complex gaseous mixtures evolved in the cementation box preclude even a moderately close control of the process and result in a non-uniform product containing a hard, brittle case badly addicted to exfoliation. In cementation as well as other processes the simplest combinations are managed with difficulty, while any such variable and complex mixtures as are produced by the destructive distillation of organic materials are absolutely uncontrollable.

Liquid Cements

The use of a liquid cementing material presents a great many advantages. The temperature of a molten bath is easy to control; it maintains itself uniformly by convection currents; and, coming into intimate contact with all parts of even a most complicated steel article, heats it rapidly with the least danger of warping. The discovery of an ideal cementing liquid is yet in the future, however; some one of the following salts or a combination of them is used at present: alkaline or alkaline earth cyanides, ferro- or ferri-cyanides, alkaline bichromates—all extremely rapid in their carburizing action. These salts are maintained at 850 to 900 deg. C. in a small cast-iron crucible in a gas or oil-fired pot furnace, the whole closely hooded to effectually remove the deadly fumes arising from the melt. The operation of carburizing is done by simply immersing the metallic article into the bath for from three to fifteen minutes, depending upon the bulk of the article and the depth of the case desired.

The chemical reactions have not yet been studied

with precision, but it seems that the (CN)₂ in contact with the iron decomposes, yielding carbon, which is absorbed into the surface layers of the metal. The time is so short, however, that the carbide thus formed has little chance to penetrate into the metal, and the result is a very thin zone (0.03 to 0.1 mm.) of hyper-eutectoid steel. Deeper zones result in very brittle and higher carbon muffs which are quite liable to split off when quenched—i. e., "exfoliate."

Often the piece to be cemented is covered with a dry or pasty mixture of these salts and then carefully heated to above the critical range in a forge until the "carburizing varnish" melts and penetrates, when a quenching follows. As with the liquid bath, the equilibrium conditions of such a process are unknown, but in gamma iron, both give a high carbon concentration in a very thin zone.

Gaseous Cements

During the researches undertaken to elucidate the mechanism of the action of cementation with wood charcoal, a number of carburizations made by heating the steel in a gas current revealed some peculiar advantages. Dr. Giolitti experimented with gases such as carbon monoxide, ethylene, methane, acetylene, and illuminating gas, and grouped them into three classes which he calls Types I, II, and III, according to the characteristics of the cemented zone which they produce. In the investigations, cylindrical pieces of a pure soft steel (0.06 per cent C.) were carburized in an electrically heated tube furnace in a stream of dry gas at various temperatures, pressures and times; at the end the pieces were polished, etched and examined under the microscope, then mounted in a lathe, and successive layers two-tenths of a millimeter thick removed and analyzed.

Cemented zones belonging to Type I are produced by the use of pure carbon monoxide. The appearance of the edge is shown at 75 diameters in Fig. 5 (reproduced from Giolitti, Fig. 27), the carbon concentration of which (as revealed by the analyses of the successive layers turned from the cylinder) is shown in the "concentration-depth" diagram, Fig. 6 (reproduced from Giolitti, Fig. 25). The mechanism of this carburization has been indicated already in the discussion of the action of the solid cements, and the series of experiments with the pure gas proves it to be dependent upon the equilibrium conditions of CO:CO₂ as affected by the presence of low carbon austenite.

Mechanism of Action of Carbon Monoxide

Assume conditions as at the commencement of carbonization—we have a low-carbon steel piece at 1000 deg. C. (which we will designate as .06 Austenite) in an atmosphere of carbon monoxide. The carbon monoxide diffuses to regions of low gas concentration—that is to say, into the iron. On entering the metal it comes into molecular contact with .06Austenite, which has a higher "affinity" for the carbon of the gas than has the oxygen, and the reaction $.06\text{Austenite} + 200\text{CO} \rightarrow .08\text{Austenite} + 196\text{CO} + 2\text{CO}_2$ goes forward until equilibrium is established—which for the purposes of this equation we will assume to be with .08Austenite, and CO:CO₂ = 196:2.

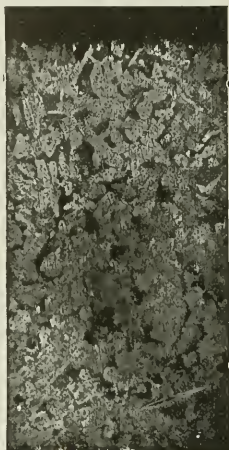


FIG. 5—MICROSECTION OF EDGE OF BAR CARBURIZED WITH CARBON MONOXIDE (75X)

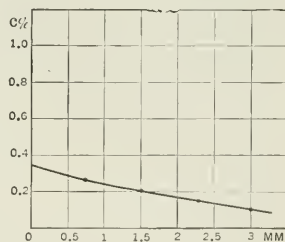


FIG. 6—CONCENTRATION-DEPTH DIAGRAM OF BAR CARBURIZED WITH CARBON MONOXIDE

The gas diffusing inwards is no longer pure CO, but contains some CO₂. It is in equilibrium with .08Austenite, but as it passes inward it comes in contact with fresh .06Austenite. Equilibria are now set up for the new locality, somewhat as follows: .06Austenite + 98CO + 1CO₂ → .07Austenite + 96CO + 2CO₂, continually decreasing the ratio CO:CO₂ as the gas penetrates farther and farther. Finally it is in equilibrium with .06Austenite, when no further carburizing action will take place.

The first "wave" of carbon monoxide entering the metal, therefore, produces a deep zone most highly carburized at the edge, and with the carbon content continually and uniformly decreasing toward the interior. A second wave of three hundred molecules of carbon monoxide entering the metal from the pure carbon monoxide atmosphere finds in the exterior layer a mixture of monoxide and dioxide in equilibrium with .08Austenite. We have assumed this concentration to be CO:CO₂ = 98:1; the additional carbon monoxide arriving enriches the mixture to the proportions CO:CO₂ = 398:1. This condition is now unstable in contact with the low carbon iron with which it is in contact, and the reaction then proceeds (.08Austenite + 398CO + 1CO₂ → .10Austenite + 394CO + 3CO₂) to equilibrium.

The second wave of gas entering the deeper and deeper zones of metal successively augments the action of the previous gas current to the point where action is again stopped by reaching equilibria for .06Austenite: CO:CO₂.

Should the successive waves be pure carbon monoxide gas and continue indefinitely, it would seem that there would be no limit to the carbon concentration attained at the edge of the steel, short of pure iron carbide. In the above, however, we have confined our attention to the inward diffusion of the CO-rich gas, which, while it carburizes, simultaneously enriches the carbon-dioxide concentration at the inner portions of the steel. This carbon dioxide will consequently diffuse outward, to regions of lower concentration, finally reaching that region of lowest concentration existing in the carburizing gas. The continual escape of this carbon dioxide from the steel establishes a certain ratio CO:CO₂ at the surface of the metal, which is really the supply of the successive waves of gas entering the metal.

The highest carbon concentration attainable by the use of carbon monoxide may be called XAustenite, and it is that austenite which is stable with exactly the same CO:CO₂ concentration which exists in the cementing gas enveloping the articles. The limiting carbon concentration attained in a cementation by carbon monoxide is, therefore, dependent upon the equilibrium constant, and not upon the maximum solubility of cementite in gamma iron.

The equilibrium represented by XAustenite is approached in the outer layer of steel with extreme slowness, owing to the counter effect of carbon dioxide diffusing from the lower carbon austenite within toward the gaseous atmosphere. For as the action of carbon monoxide going inward is a carburization, for like reasons a stream of carbon dioxide coming out will decarburize. Indeed, Benedicks⁸ shows that this equilibrium may be had in the end only by the additional precaution of keeping the temperature *rigorously* constant during the whole process.

The actual value of XAustenite varies with the equilibrium conditions; that is to say, anything which will shift the reaction ($2\text{CO} + 3\text{Fe} \rightleftharpoons \text{Fe}_3\text{C} + \text{CO}_2$) to the right will increase the carbon concentration in the muff, and vice versa. Higher carbon cases may be expected



FIG. 7—MICROSECTION OF
EDGE OF BAR CARBURIZED
WITH ETHYLENE, 5 HR.
AT 1050 DEG. C.

shows the existence of three distinct zones shown plainly in the micrograph, Fig. 7 (reproduced from Giolitti, Fig. 38), and the corresponding concentration-depth diagram, Fig. 8 (reproduced from Giolitti, Fig. 37), which are produced by a four-hour cementation in ethylene at 1050 deg. C.

Dr. Giolitti does not fully develop the theory of the mechanism of carburization of zones of his Type II. The action of carbon monoxide may not appear to be simple, but the equilibria C:CO:CO₂ have been quite well worked out in comparison with those of the systems Hydrocarbon:H:C. In general, the specific carburization by means of hydrocarbons may be said to rest upon the relation $\text{C}_n\text{H}_m \rightleftharpoons \text{C}_n\text{H}_x + \text{C}_m\text{H}_2 + \text{C}_k\text{H}_l +$

from a decrease in temperature, an increase in pressure, or a larger supply of carbon monoxide—a higher gas velocity. The first two statements follow directly from the principle of Le Chatelier, inasmuch as the reaction is exothermic and attendant with decrease in volume. From a practical standpoint, however, the theoretical increase in carbon concentration attainable at lower temperatures is more than nullified by the consequent lowering of speed with which the system approaches equilibrium. A higher gas velocity will undoubtedly give a higher concentration simply because the carbon dioxide produced by the reaction given above is swept away as rapidly as it is liberated. This largely increases the ratio CO:CO₂ existing at the surface of the metal, with attendant increase in carbon content of XAustenite.

Mechanism of Action of Hydrocarbons

Cemented zones belonging to Giolitti's Type II are produced by the use of ethylene, methane, acetylene, or other hydrocarbons which decompose at elevated temperatures when in contact with iron, depositing a larger or smaller quantity of finest carbon on the outside of the specimen. The distinctive feature of cementations of Type II is the possession of a hypereutectoid case, whereas Type I always produces hypoeutectoid zones. In addition to this characteristic, a slowly cooled zone of Type II

.... + + yH_2 + xC . At the high temperatures of industrial cementation (1000 to 1100 deg. C.) the decomposition products represent a very complex series of compounds.

As before noted, the decomposition upon entering the steel is so rapid that a deposit of carbon is formed on the outside of the steel much more rapidly than it can diffuse into the metal. This lavish deposition of carbon evidently continues as the gases penetrate farther, the direct action of the decomposing gases being intensified by the presence of the excess of carbon deposited on the surface of the sample as well as being possibly reinforced by the diffusion of the carbon bodily into the steel (perhaps a considerable factor in this instance owing to the fine subdivision and the intimate contact of the sooty deposit). For these reasons a high carbon concentration is obtained with a zone of χ Austenite of considerable thickness (1 mm.+).

The depth of the entire carbonization and the carbon content of χ Austenite will vary widely with variations in the velocity of the decomposition reactions and the conditions of equilibrium, being increased by an increase in the quantity of gas supplied per unit time, the temperature and pressure, and further affected by such variables as the composition of the original hydrocarbon gas and of the steel. Owing to such conditions, the process is hard to control, and such gases cannot be used undiluted for work where some particular depth or percentage carbon is required.

Liquation of Cementite and Ferrite

Notwithstanding the slight direct applicability to industrial uses, cements of Type II produce such extraordinary carbon distributions as to demand further discussion. Should such a specimen as that analyzed and plotted in Fig. 8 be quenched immediately after the cementation is finished, the outer case of χ Austenite containing 1.35 per cent carbon would be underlain by a zone where the carbon content falls off rapidly and continuously to the unaffected core. Such quenching suppresses the pearlitic band so prominent in Fig. 7.

However, when a temperature is reached where the carbon content of χ Austenite exactly equals the maximum solubility of cementite in gamma iron, the necessary time will be provided during a slower cooling for primary cementite crystals to be deposited from the now saturated mother solution at the outer edge of the metal. With further lowering of the temperature, the solubility of cementite in Austenite is further reduced, and the lower carbon zones immediately underlying the saturated edge start precipitating their cementite. This collects about the first deposited cementite crystals, which act as nuclei, thus tending to enrich the outer layer in carbon.

Conditions at the center of the specimen are exactly similar with reference to the primary ferrite crystals depositing from the low-carbon austenite at that region. As the temperature approaches 690 deg. C., therefore, the ferrite crystals in the low-carbon zones migrate inward slightly, collecting upon the

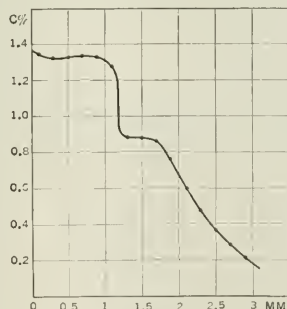


FIG. 8 — CONCENTRATION-DEPTH DIAGRAM OF BAR CARBURIZED WITH ETHYLENE, 5 HR. AT 1050 DEG. C.

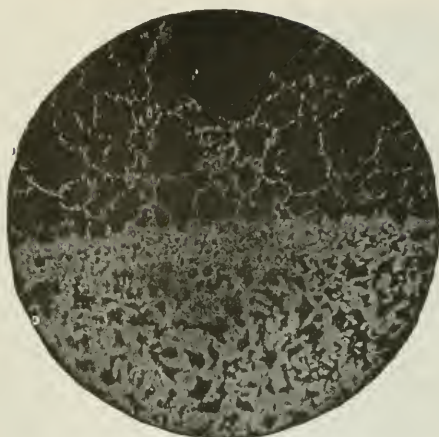


FIG. 9—MICROSECTION OF EDGE OF BAR CARBURIZED AT ABOUT 800 DEG. C.

nuclei furnished by the crystals precipitated previously.

The result of a slow cooling is the production of three distinct zones; namely, a high carbon case, a low carbon core, and between these two a band of pearlite in the neighborhood of 1 mm. thick. This latter zone is the result of liquation—the region is impoverished by the migration of cementite outwards and ferrite inwards.

Cementation in Beta Iron

Another manner of variation in the carbon content results from low-temperature cementations in gases of Type II. Let the temperature be such that the ferrite crystals of the original normal steel are in the beta modification—say, 800 deg. C. In this case the carbon precipitated on and within the iron is absorbed only at those isolated portions previously occupied by the pearlite segregations, the iron of which is now in the gamma form. The carbon content of the exterior portion of the iron is, therefore, increased by virtue of absorption and diffusion with extreme slowness. This outer edge finally reaches a carbon content representing that which transforms it into gamma iron at the temperature in question—0.4 per cent carbon in this instance—where after cementation will go forward rapidly. The inner limit of the gamma iron zone is being continually pushed toward the center of the specimen at a low rate, and the resulting case has as before three distinct zones, as follows: a muff of high carbon, practically χ Austenite; a low carbon core; and a narrow band where the carbon content increases very rapidly. The characteristics of this class of carburized

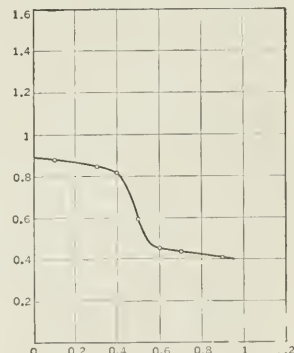


FIG. 10 — CONCENTRATION-DEPTH DIAGRAM OF BAR CARBURIZED WITH ETHYLENE, 4 HR. AT 800 DEG. C.

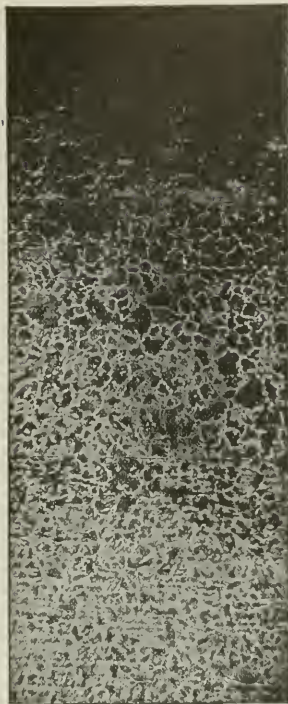


FIG. 11—MICROSECTION OF EDGE OF BAR CARBURIZED WITH GIO-LITTI'S MIXED CEMENT (50X), 2 HR. AT 1000 DEG. C.

muffs are illustrated in the micrograph at 60 magnifications, Fig. 9 (reproduced from Giolitti, Fig. 35), and the concentration-depth diagram, Fig. 10 (reproduced from Giolitti, Fig. 43).

Zones of Type III

Cemented zones belonging to Gio-litti's Type III are produced by illuminating gas or various mixtures of gases of Types I and II. At high temperatures these give rise to carburized cases of varying thicknesses approximating eutectoid composition at the exterior, underlain by steel of constantly and uniformly decreasing carbon content merging into the unaffected core. The characteristics of this class of carburized zones are illustrated in the micrograph, Fig. 11 (reproduced from Giolitti, Fig. 142), and the concentration-depth diagram,

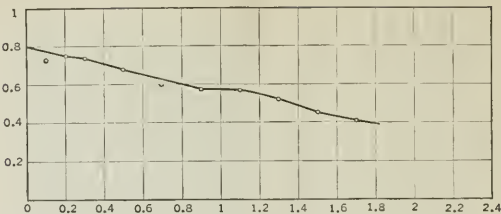


FIG. 12—CONCENTRATION-DEPTH DIAGRAM OF BAR CARBURIZED WITH CARBON MONOXIDE PLUS 3.1 PER CENT ETHYLENE, 4 HR. AT 1000 DEG. C.

There will, however, be a slight segregation of ferrite on slow cooling, but this is of much smaller importance in these deep zones than in the shallow ones of Type II, because the discontinuity thus formed is of limited extent and therefore represents a considerably smaller proportion of the whole. Even such segregation about nuclei of ferrite crystals may be obviated by quenching from the carburizing temperature. It is also of importance that this temperature be well above A_{c1} , else concentration depth curves similar to those of Fig. 10 are formed, and for precisely the same reasons.

Practice of Cementation by Gases

The many advantages accruing from the use of gaseous cements have only been recently realized. Formerly such methods were confined to the production of very deep cementations (20 mm. +) on armor plate. The Machlet furnace, Fig. 13 (reproduced from Giolitti, Fig. 126), has now made possible the use of gaseous cements in small establishments. This is a gas-fired, horizontal, cylindrical furnace, containing a slowly rotating cylindrical steel crucible (2) concentric with the furnace and surrounded by the flames. The crucible has gas openings at the center of each end (33 and 49) in order that a steady stream of carburizing gas may be passed through the hot crucible in which are rumbled the small articles for carburization. At the completion of the run, the contents of the furnace are discharged rapidly by removing the crucible end (32) and raking them out, when they fall directly into the quenching medium (84).

The gas used in such furnaces would be preferably pure carbon monoxide were it not as already pointed

Fig. 12) reproduced from Giolitti, Fig. 45).

Type III is seen to be "intermediate" between Types I and II, and in fact is the result of a plain carbon monoxide cementation (Type I) "intensified" by the action of the pulverulent carbon deposited on the surface and in the exterior layers of the steel by the decomposing hydrocarbons.

Referring to the explanation of the mechanism of the carburization by carbon monoxide, it is seen that the equilibrium of the system ($C:CO:CO_2$) is maintained continuously in the outer layers of the steel by the constant deposition of carbon from the hydrocarbons; this carbon is being continually transferred inwards by the diffusing $CO:CO_2$ gas. Carbon monoxide, in fact, appears to act with maximum intensity in the immediate proximity of free carbon, diminishing with the increasing time necessary to diffuse through the larger distances between the zone of enrichment and the zone of regeneration. In other words, the result of an industrial cementation, which represents some stage before complete equilibrium, depends upon the speed of the diffusion and reactions involved.

In Type III the undesirable discontinuous variations in carbon concentration of Type II are eliminated because the hypereutectoid outer zone is non-existent. They may, therefore, be cooled slowly from the austenitic condition without a segregation of the cementite.

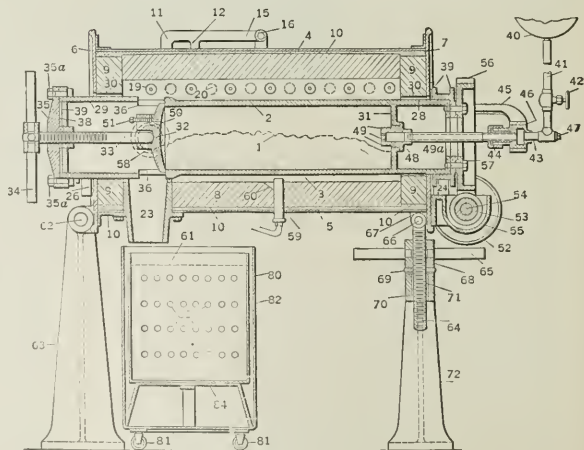


FIG. 13—LONGITUDINAL SECTION OF MACHLET FURNACE

out, that this gas alone or as produced in the ordinary mixed gas producer acts very slowly, that is, it is too "mild." It is usual to enrich such producer gas by pumping a regulated quantity of it through a steam-heated bath of petroleum. The vaporization of the hydrocarbons, when properly controlled, will enrich the producer gas to a point where the gaseous mixture becomes a "sudden" cement, and will precipitate carbon on the surface of the pieces. Under these conditions a case of the "intermediate" Type III described above is produced.

By the regulation of the various percentages of vaporized fuel oil and producer gas entering the retort, the concentration-depth characteristics of the carbonization may be closely controlled. In normal work, a penetration of from 0.7 to 1.2 mm. may be obtained in an hour with a maximum carbon concentration approaching 0.9 per cent. Such a case, by the way, is ample for 99 per cent of all machine parts subjected to partial carbonization.

On the whole, the Machlet furnace is very good for small intricate pieces, but less so for larger, more bulky or flat articles which, in addition, are perhaps not to be cemented over the whole surface. For larger pieces more elaborate furnaces are installed, very similar to those used for "mixed" cements which will be described later.

Mixed Cements

It has been seen that a gaseous cement consisting of a small percentage of hydrocarbons mixed with carbon monoxide raises the concentration of the carbon in the cemented zone above that to be expected from the latter gas alone. Successive additions of hydrocarbons proportionately increase the carbon content up to a point where a carbon deposit is formed on the steel—that is to say, where gas decomposes faster than it passes through the carbon monoxide stage and thence into the steel. Beyond this point the action is like that of a solid cement—the granular charcoal being merely replaced by the finely divided soot which is deposited on the steel.

Thus there is hardly any line of demarcation between the action of some gaseous mixtures and a "mixed" cement consisting of a solid cement acting in conjunction with a gas current—or more particularly as recommended by Dr. Giolitti, a current of carbon dioxide passing through a retort containing granular wood charcoal. In general, at the normal temperatures of cementation (at which steel exists as austenite), atmospheric pressure, and in the short time allowed, Dr. Giolitti's mixed cement produces zones of the intermediate Type III mentioned above, doubtless in all respects the most desirable kind of carbonization yet devised.

The theory of the action of this mixed cement has been sufficiently discussed in the preceding pages; the advantages accruing with its use may be profitably listed. A mixed cement consisting of a current of $\text{CO}:\text{CO}_2$ over hot carbon (wood charcoal) has a perfectly definite and simple composition, and will add absolutely nothing but carbon to the steel. It is non-exhaustible. The reactions lead to equilibria corresponding to definite carbon concentrations in the austenite, and consequently the results can be easily and closely predicted for wide variations in the carbon content in the original steel without the use of "spies." The diffusion of $\text{CO}:\text{CO}_2$ into the steel is rapid, which results in a high velocity of penetration of the carbon, and great uniformity and continuity in its distribution. The sur-

faces are perfectly unaltered; and carburization is uniform over the most intricate shapes. Speed of carburizing is attained by charging hot metal and hot granular carbon into a hot muffle, which in addition reduces the danger of distortion to a minimum.

Practice of Cementation with Mixed Cements

The furnaces used for "mixed" cements are of the muffle type—horizontal muffles for small pieces, and vertical muffles or retorts for larger. In the former case a cast iron retort shown in cross section in Fig. 14 (reproduced from Giolitti, Figs. 132 and 133), is mounted in a suitable gas-fired oven. At the front is bolted an extension containing flanged outlets, top and bottom, for the entrance and exit of the granular cement. The doors are hinged in such a way as to allow partial filling of the muffle. Four perforated pipes for the gas supply enter through the front end and lie along the floor of the retort. Upon these pipes are placed ten centimeters of granular carbon, filling the retort up to the first projection on the side walls, upon which is then slid a rack containing the pieces to be carburized, and the remaining space filled with carbon, pushed to the rear by a special hoe resting on the upper projections and operating through the top half of the hinged door. The filling operations are much accelerated owing to the fact that hot granulated carbon will "run" out quite flat, acting somewhat like a mobile liquid.

The gas furnished these retorts is dry carbon dioxide from the ordinary high-pressure drums, up to 1 cu. ft. per hour of the gas being required per square foot of the surface to be carburized. Passing through the 10 cm. of hot carbon intervening between the pipes and the rack of steel articles is quite sufficient for the equilibrium of the system $\text{C}:\text{CO}:\text{CO}_2$ to be established. On completion of the process (two hours are required for cases up to 1 mm. thick) the drain in the bottom is opened, the hot carbon readily runs out into a tank placed below for its reception, the rack containing the cemented articles withdrawn, quenched, and replaced by another from a preheating oven, and the tank full of hot carbon then discharged back into the retort through the opening in the top. These operations are effected in not more than fifteen minutes, a carburizing temperature of 1000 deg. C. is regained after twenty minutes more—in this way nine complete operations may be effected in twenty-four hours.

For the cementation of larger quantities of pieces, or of large flat pieces such as gear wheels, more elaborate furnaces similar to Fig. 15 are constructed (reproduced from Giolitti, Fig. 130). (In passing it should be

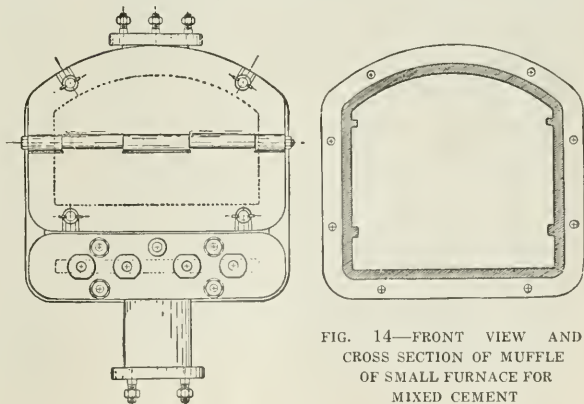


FIG. 14—FRONT VIEW AND CROSS SECTION OF MUFFLE OF SMALL FURNACE FOR MIXED CEMENT

stated that furnaces of exactly the same type are in use for cementation with gaseous cements.) These furnaces have fixed vertical retorts of steel (A) set in a refractory tube for protection against flame erosion. Heating is effected by producer gas acting in connection with regenerative checkerwork.

The bottom of the retort is closed by a close fitting hopper E and perforated plate F, upon which the pieces to be cemented are stacked. In order to facilitate charging and discharging, the entire bottom of the retort may be raised or lowered as desired by the hydraulic plunger L, when a column of preheated cylindrical pieces may be stacked up, or loaded in by baskets. Hot granular carbon is then run into the retort, which owing to its mobility at the elevated temperature, entirely and effectually submerges all the pieces, entering into all irregularities of the surface with great ease and surety. The cover is then closed, and a stream of carbon dioxide enters by a pipe connection attached to the base D.

As in the case of the smaller horizontal retorts, the carburizing temperature is reached in ten minutes, a temperature control of 10 deg. is maintained, and a case 1 mm. thick can be obtained in two hours. Discharging is preceded by drawing off the carbon through a spout at the bottom of the retort B into a tank O, and removing the cover. The hydraulic plunger then lifts the carburized contents up to the level of the working platform where they are removed and quenched. In this manner from ten to twenty cementations can be effected in a day of twenty-four hours (depending upon the depth of a case required), turning out from one to five tons of material at a maximum cost of one cent per pound—one-fifth that of carburization in boxes.

In installations of this kind perfect uniformity of cementing action is maintained easily by attention to the following details: charge the pieces from a preheating furnace at a uniform temperature; provide a uniform, slow circulation of the carbon monoxide; have clean, dust-free charcoal of about rice size; maintain a uniform carburization temperature by careful design and operation of the furnace.

Exceptionally good results are had in deep zones by a long cementation with carbon—which produces a hypereutectoid zone—then, without interrupting the flow of gas, withdraw the carbon from about the steel pieces and work with carbon monoxide alone for some time. The gas at the end of the operation acts as an "equalizer," transferring the carbon from the high concentration at the edge into deeper and deeper zones. The hypereutectoid zone disappears first, and if the process is continued long enough, the eutectoid zone also is impoverished, approaching the equilibrium of the familiar system $\text{X Austenite}:\text{CO}:\text{CO}_2$, but from the opposite direction.

Deeper zones may also be had in a more direct man-

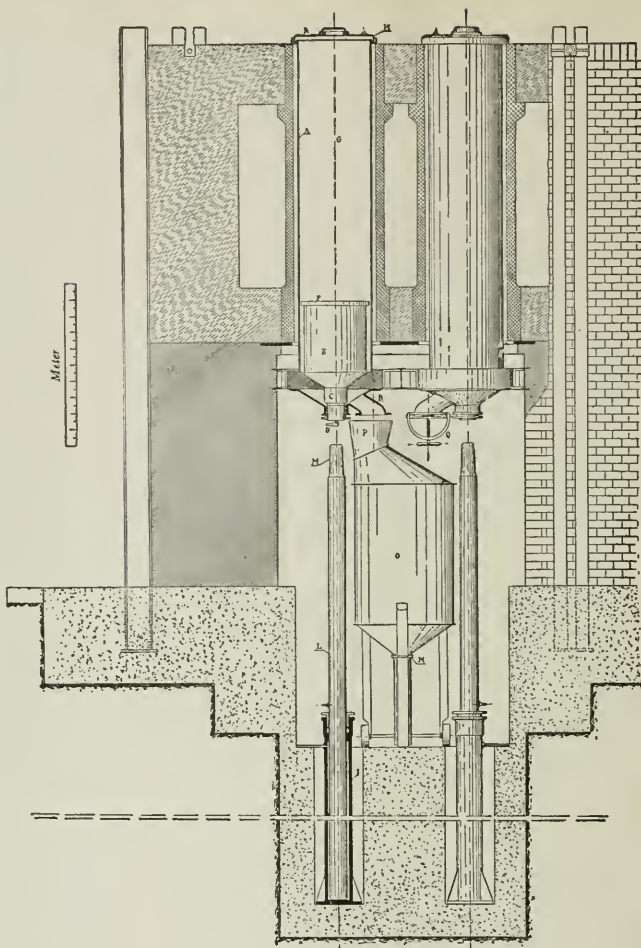


FIG. 15—SECTIONAL ELEVATION OF LARGE VERTICAL ANSALDO FURNACE FOR MIXED CEMENT

ner by diminishing the partial pressure of the carbon monoxide in the mixture by the introduction of an inert gas—this may easily be done by replacing the stream of carbon dioxide entering the retort with air. The resulting gas has a large amount of "inert" nitrogen; as an instance of the operation of such a cement, it may be said that a twelve-hour cementation at 1100 deg. C. gives a very deep zone of very uniform hypoeutectoid steel.

Additional Problems in Carbonization

Certain features of the text have not been dwelt upon here. Dr. Giolitti presents data regarding the cementation of special steels—admittedly fragmentary owing to the fact that such processes are confined in large part to secret methods for the manufacture of ordnance and armor.

Again, Dr. Giolitti mentions the fact that large accumulations of free cementite crystals result from oscillations in temperature during cementation. This experimental fact is unquestioned, but the theoretical explanation advanced by him is not altogether convincing.

Work in the metallurgical laboratory of the University of Cincinnati is now in progress by which it is hoped to shed more light upon this matter.

A perplexing and most troublesome phenomenon attendant with the use of cemented steel objects is the exfoliation or splitting, of the carburized zone from the body of the piece during quenching or in use. Dr. Giolitti shows that these failures occur at points where a sudden and discontinuous variation in carbon content occurs in the carburized zone—as in the case of the middle zone in cementations of Type II. He explains the facts by referring in a more or less vague way to the abrupt differences of “mechanical properties” which exist in the neighborhood of these layers. This matter has been much clarified recently by Mr. E. P. Stenger, instructor in Metallurgy at the University of Cincinnati, in an important research, which will be published in a succeeding issue in this journal.

Cincinnati, Ohio.

Chemical Porcelain; Its Production and Quality*

By Professor Chas. F. Binns

The present tumult in Europe has focussed attention upon many articles of commerce for which America has depended upon importations, and among these articles chemical porcelain occupies an important place. Germany has had almost a monopoly of the production of this ware and the porcelains of Berlin and Meissen are accepted as of standard quality. Denmark has recently entered the field with an excellent porcelain and Japan is offering a supply of wares which, if not equal to the best, are capable of use. One or two attempts have been made in the United States to meet the demand, but so far the desired quality has not been reached.

In opening a discussion upon this subject the endeavor should be made to establish a clear conception of the material to be considered, what it is, how it comes into being, how its quality is acquired and upon what this depends. In short, to take as complete a view of the field as may be found possible within the allotted time.

The substance known as porcelain owes its name to a supposed similarity to a shell, cyprea porcellana, which was used in the sixteenth century as an object of art. This shell bears a similarity in shape to a hog's back, and this it was which called forth the name “porcellana.” The name was finally passed on to the shell-like substance of which the origin was then shrouded in obscurity. Perhaps in allusion to this nomenclature an early Italian writer stated that porcelain was composed of eggs, shells of marine locusts and like ingredients. It was further credited with the property of bursting in pieces if used as a receptacle for poison. This supposed property doubtless enhanced the value of porcelain vessels at that time.

The original ware was made by the Chinese, who reached the perfection of their art in the fourteenth century. The first hard porcelain of Europe was made at Meissen in Saxony in 1710, though this had been preceded in France by the manufacture of soft porcelain.

The manufacture of porcelain, while doubtless perfected by accident, exhibits a development which must be interesting to chemists. In all the ceramic production of the East the firing was originally performed under reducing conditions. The black glaze of the Greeks was largely composed of ferrous oxide, the gray ware of the Romans was colored by carbon and ferrous

oxide together, the alkaline glaze of the Mohammedan peoples was made possible by a reducing fire which dissipated the fumes of sulphur, and in like manner the Chinese resorted to the reducing fire in order to change the natural yellow tone of their clays, which was caused by the presence of ferric oxide, to a grayish blue tone which resulted from a conversion of this oxide to the ferrous form.

But now a further condition arose. In order to produce a brilliant glaze, materials must be found which would not be influenced by reduction. This eliminated the compounds of lead, tin and zinc. The consequence was that the only glaze which met the conditions was one which demanded an extremely high temperature for perfect maturity and brilliance. Such a glaze was at first made by grinding a pegmatic and mixing it with wood ashes. The result is now attained by mixing feldspar, marble dust, clay and quartz. Thus it is not too much to say that the philosophy of porcelain production is founded upon the reducing fire and the hard glaze. The underlying body was selected or prepared to meet the conditions imposed by the glaze and this in turn was compelled to meet the demands of the reducing fire. The body and glaze contain the same oxides, silica, alumina, lime and potash. Nothing else is essential. Almost everything else is detrimental.

In the early practice the glaze, ground in water to a creamy liquid, was laid on the raw clay with a brush. In modern times the clay is ignited to about 1000 deg. C. so as to facilitate handling. It is then dipped into the fluid glaze and the finishing fire, approximately 1430 deg. C., matures body and glaze together. A low temperature is necessary for the first burning because if the ferric oxide in the clay should be inclosed in a vitreous or non-permeable mass the subsequent reducing fire would have no effect upon it and the yellow tone would not be changed to the necessary blue.

The Chinese potters found a pure white clay at the top of a certain mountain which was called “Kao Ling,” meaning Lofty Hill. The early French missionaries took this name to be that of the clay itself and so the name became anglicized into “kaolin” and has passed into mineralogy in the form of “kaolinite.” Kaolinite is a rare form of a hydrous aluminum silicate which crystallizes in horizontal plates. The substance known as kaolin is a residual clay which results from the decomposition of feldspars. Kaolinite crystals are sometimes present, but for the most part the clay is massive and contains undecomposed feldspar grains and some quartz. It is washed at the mine and while it varies to some extent in purity the clays which are offered on the market approach closely to the composition of kaolinite. The usual impurities consist of ferric oxide and small quantities of lime, feldspar, and quartz. The iron, even to the amount of one per cent, need not be objectionable because, as already explained, the reducing action of the kiln causes it to develop the bluish shade which is characteristic of porcelain. Kaolins are usually rather coarse in grain and possess only a low plasticity. For this reason a more plastic clay is sometimes added to the mixture.

Kaolin alone is extremely refractory and therefore some ingredient must be used which will, upon heating, impart the impervious quality necessary to a perfect porcelain. Feldspar, usually and almost invariably a potash feldspar, orthoclase or microcline, is used. A curious fact may be noticed in passing; soda feldspar, while producing vitrification and translucency, will not make a sonorous porcelain. The ware containing soda as a flux sounds dead when struck, while the potash porcelain gives out a clear musical note. No explanation has been offered to account for this phenomenon.

In addition to the clay and feldspar a small amount

*A paper read before the New York Section of the American Electrochemical Society in joint session with the New York Sections of the American Chemical Society and Society of Chemical Industry on Feb. 9, 1917.

of quartz is added to the mixture and two or three per cent of calcium carbonate. The last-named ingredient is not invariably present, but it helps the purity of the color, contributes to the vitrification and increases the strength of the ware.

The ingredients are usually tested with great care. In the best practice the analysis of the materials is carefully checked. The clay is apt to vary in the respective amounts of feldspar and quartz grains contained and the feldspar will vary as to the percentage of potash. This is important because it is solely for its potash content that the feldspar is used. Feldspar always contains quartz inclusions so that unless the mineral is carefully selected before grinding the content of quartz will vary considerably. This, of course, affects the percentage of potash. Furthermore, feldspars are undergoing a continual decomposition. Some of the potash is being leached out, leaving a residue of clay. Thus it is not uncommon to find a commercial feldspar containing only 13 or 14 per cent of potash, while the theoretical percentage is 16.9.

A good grade of quartz is usually 98-99 per cent silica and is taken to be pure. The clay is received at the manufactory supposedly ready for use. It has been washed and floated at the mine and is shipped dry. The feldspar and quartz are ground by the miller and are received in the form of dry powder. The proper mixture having been determined, a point which will be discussed later, the ingredients are weighed out in batches of convenient size.

At this point it may be worth while to explain the different methods of clay mixing because an understanding of these will materially help in forming an opinion upon results.

The American plan is to feed the whole charge of weighed material into a tank known as a blunger. This is fitted with one or two vertical shafts which are furnished with steel blades. An abundance of water is used and a brisk motion is maintained until the whole charge of clay and other materials is reduced to a thin fluid. This is then strained through screens of brass wire cloth or silk lawn having 100 or 120 meshes to the linear inch. The material can be used in the liquid form or the water can be expressed and the clay passed on to the workmen.

The process which prevails in England is to grind each non-plastic substance separately in water and to blunge the clays each by itself. The mixing is then performed by measure, the specific gravity of each fluid being adjusted. Thus no material is used which is not fine enough to remain suspended in water.

The plan adopted in France and Germany is different. Like the English potters the Continental workers recognize the importance of grinding, but they usually weigh the batch and grind it, while the English mix the batch from an already ground fluid stock. In Germany either the whole batch is ground in a cylinder or the quartz and feldspar are ground and mixed with the clay which has meanwhile been blunged and screened. The potters of the Old World have long recognized that fine wares cannot be made except from very finely ground materials. The American potter finds this too tedious and expensive. He goes to a trade miller and buys pulverized quartz and feldspar presumably ready for use. It is only necessary to stir the mix with water and the clay is ready. Lest it be thought that this is an unfair comparison it should be added that the American potter is not attempting to make porcelain. He makes a strong earthenware which he names semi-porcelain, and when he essays to make a translucent china he has to grind his materials fine, as is done in Europe.

As a part of the process it is the usual practice everywhere to pass the fluid clay—known as slip—through

magnetic fields to extract the iron dust which has found its way into the materials. If left in the clay this iron would produce minute black specks.

The clay body is shaped into the required wares by one of several processes. The clay is formed on the potter's wheel by hand, a process which is not now in commercial use to any great extent. Or the clay is shaped in a mold made of plaster of paris; this is the common method for table wares and large pieces. Or the clay is dried to a moist dust and pressed into steel molds; this is in extensive use for the production of wall tile and electrical insulators. Or the fluid clay is shaped in plaster molds by the process of casting; as this process is used for the production of chemical porcelain, it will be well to describe it more fully. First as to the preparation of the slip. It has already been shown that the first stage of the mixing results in slip from which clay is afterward prepared by expressing a part of the water.

Slip of this character can be thickened by subsidence, decantation and evaporation until it becomes thick enough for use in casting, but even then, to be fluid enough to pour, it must contain 50 to 60 per cent water. It has been found, however, that by the addition of *electrolyte*, which deflocculates the clay, a fluid slip can be produced with a water content of only 30 to 40 per cent or about 10 per cent higher than the water content of the clay when in plastic form. This expedient results, of course, in very much less shrinkage in drying and burning, moreover it makes the working of the slip much easier. There are two ways of performing the operation, for it will not suffice merely to add electrolyte to a thick slip. In the original plan the proper charge of material was weighed and fed to a grinding mill. A measured quantity of water was added and about 1 per cent of a mixture of equal parts of sodium silicate and dry sodium carbonate. The whole batch was then ground until fine enough for use. The objection to this method is that as the addition of more water would spoil the slip it was necessary to screen it while in the viscous condition which is demanded for proper use. This involved a great deal of trouble and much material was lost. The better plan is to take some of the slip which has been made in the regular way, pump it through the filter press to extract the water and then to reduce the plastic, stiffened clay to slip again. It has already been screened, so that a second refining is not necessary. The plastic clay is weighed, 10 per cent of water added with the proper amount of electrolyte and the whole charge placed in a mill to be reduced to a smooth viscous slip. This is simply run out when ready and is supplied to the potters for use. The slip, when in proper condition, should weigh 1.60 grams per cc.

The process of casting is simple, but usually arouses interest and inquiry, because it is different from the casting of metals. The casting of pottery depends upon the use of porous molds. Molds made of plaster of paris possess this property when dry. The slip is poured into the mold and suction at once begins. The porous walls absorb the water rapidly and the clay which was held in suspension is built up, particle by particle, in an even coating over the inner wall of the mold. More slip being supplied the process of building continues until the coating of clay reaches the required thickness. When this is the case the mold is emptied of the superfluous slip and set aside to drain. In a few moments the clay vessel will have become dry enough to shrink away from the walls of the mold. It can then be removed, dried thoroughly, finished smooth on the edge and burned. The handle of the casserole and the little ring on the crucible cover are made separately and fastened to the body pieces by using a little thick slip as a cement.

The matter of the composition of the porcelain body may now be discussed. As already stated, the body may contain clay of two kinds, plastic and non-plastic; ground feldspar and ground quartz. The small quantity of calcium carbonate may be ignored. It is simply added in the form of whiting as may be required by the terms of the recipe in use.

The best chemical porcelains contain about 80 per cent clay, 10 per cent feldspar and 10 per cent quartz. These figures mean nothing to a layman, but for the purpose of illustration they may be compared with a standard American china mixture (Fig. 1). This is:

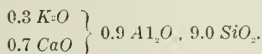
Kaolin	27
Plastic clay	15
Ground feldspar	22
Ground quartz	36

Or a standard earthenware mixture which is:

Kaolin	25
Plastic clay	20
Ground feldspar	15
Ground quartz	40

In addition to these marked differences in composition there are differences introduced by method. The earthenware is mixed from commercial materials without further preparation, the china and the porcelain bodies are both ground to an additional fineness. Further, the earthenware and china bodies are manufactured by the two-fire process, the body being matured first and the glaze fused upon it afterward at a lower temperature. The porcelain is matured at one-fire only, body and glaze undergoing the same burning. And yet, again, the earthenware is exposed to a temperature of pyrometric cone 8 or 1290 deg. C. for the body and cone 6 or 1250 deg. C. for the glaze; the china to cone 10, 1350 deg. C. for the body and cone 6, 1250 deg. C. for glaze; the porcelain to cone 16, 1450 deg. C. for both body and glaze.

It will not be necessary to discuss the composition of the more fusible glazes. They owe their low softening point to the presence of lead oxide and boric acid. The porcelain glaze, however, may be considered more fully. A glaze for chemical porcelain, to become smooth and brilliant at or about 1450 deg. should correspond to the empirical formula:



This will be produced by

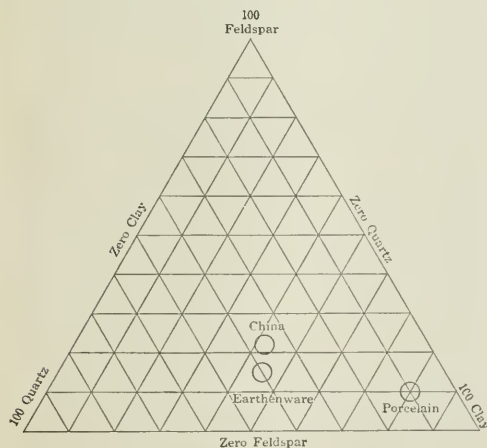


FIG. 1.—TRIAXIAL DIAGRAM

Feldspar	22 parts
Whiting	9
Clay	21
Quartz	48

The materials are weighed dry and ground in water to a creamy liquid. A fine screen arrests all unground particles, and the dehydrated clay ware which is porous and fragile is dipped rapidly and dried.

The technique of porcelain firing is very intricate and important. The earthenware and china made in this country being burned on the two-fire plan, there has been no opportunity to acquire the specialized skill which porcelain demands. The difference is this: When any ware is brought to its full maturity while in the unglazed or biscuit condition the pieces can be packed in fine sand or pulverized quartz. All vitrified wares become flexible when at the maximum temperature and the more so as the vitrification is to be the more perfect. Earthenware may be considered almost self-supporting. China requires very careful adjustment and assistance. In burning porcelain, however, no support other than a mere standing place is possible because the pieces are covered with glaze. Any contact between a glazed surface and a support will cause a permanent connection on cooling and will probably break the ware. An examination of any piece of porcelain will reveal a dry surface where the vessel has stood. Porcelain cups and saucers can be easily distinguished from china cups and saucers by this fact. Crucibles are unglazed at the bottom, evaporating dishes are burned upside down and have a dry rim. Casseroles are also burned in this position and the handle has a dry patch at the end, supposedly left as a convenient point for a mark or number, but in reality as a place for a support which will not stick to the unglazed part.

The French and Germans have brought the art of setting their wares to great perfection. They have accumulated a fund of experience and an enormous equipment of appliances of which American potters have no conception. Added to the fact of the viscous, tender surface there is that of the shrinkage. Clay wares are reduced in size in burning according to the nature of the body and the completeness of the vitrification. Cast pieces will shrink from one-eighth to one-sixth in size. Therefore, when true shape is expected supports of raw clay must be prepared which will contract to the same extent and at the same rate as the piece supported. Thus delicate cups are set on clay rings in an inverted position. Large pieces are set on refractory cones which are made at such an angle that the piece will slide over the surface as it contracts without being subject to too much friction. All these facts tend to show how much there is to be learned in this country if the production of porcelain is to proceed.

It now seems to be in order to inquire in what especial condition or circumstance the quality of chemical porcelain resides. The demands upon wares of this type are: First—Low thermal expansion in order to secure resistance to temperature changes. Second—Insolubility under drastic treatment with acids and alkalis. Third—A glaze difficult of fusion to permit heating without softening. The first condition is imposed upon the body, the last two upon the glaze. A pottery body, however it may be composed, undergoes certain changes when heated. These changes are concerned, first, with the dehydration of the clay and the expulsion of the combined water; second, the softening of the feldspar grains and the beginning of their attack upon the less fusible particles; third, the change of the quartz grains through cristobalite to quartz glass, and, lastly, the formation, under the solvent influence of the feldspar, of new combinations, of which sillimanite is the most

important. The due progress of these reactions is governed by several things—the mixture, or proportion of the several ingredients, the temperature of the firing and the time taken to reach that temperature.

The heat work of the kilns is gaged by the pyrometric cones which were first produced by Seger, the German ceramist, about 30 years ago. These are not intended to be calibrated in degrees of temperature, for they are greatly influenced by the duration of the burning process. They are, however, a great boon to the practical burner and, moreover, constitute an alphabet of burning information which is most valuable. One can easily understand the significance of a cone 1 kiln or a cone 10 kiln, whereas the terms of temperature do not express the same thing nor are they so readily grasped.

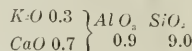
A china body made in this country* is burned to cone 10. In this case the material does not seem to have been very finely ground and the temperature has not been sufficiently high to accomplish much in the way of new combinations. This china is too glassy to meet the conditions which are imposed upon chemical ware, furthermore the glaze is too fusible. This is a compound containing both lead oxide and boric acid. It is probably fused at less than cone 6 (approximately 1250 deg.).

Haviland porcelain made at Limoges, in France, is a true hard porcelain burned on the one-fire plan and matured at about cone 15. The glaze is hard and the body less glassy than the china, but still it will not bear the exacting tests to which chemical porcelain is subjected.

The Meissen porcelain illustrates the complete development of the structure of chemical porcelain. (A slide was shown at the meeting, magnification 190 diameters, made by Mr. A. A. Klein, petrographer of the Bureau of Standards.) It is a section of body and glaze together and beautifully illustrates the growth of crystals of silimanite from the body surface. Crystals of the same compound can be seen in the body structure together with certain masses which Mr. Klein defines as amorphous silimanite.

In this connection it is interesting to quote from a South Kensington Hand Book on English Porcelain by A. H. Church, professor of chemistry in the Royal Academy of Arts of London and an enthusiastic collector of porcelain. He says, "If we bring the microscope to aid us we shall find that all the hard porcelains have a common and distinctive structure which consists in the presence of a vast number of small, straight ended slender rods, called *belonites*, and of many minute granules called *spherulites*, both rods and granules having been formed out of the original materials, but not pre-existing in them." The book from which this quotation is made was published in 1885, but there does not seem to have been much attention paid to the statement quoted, or to the facts set forth, until recent investigators, Mellor in England being probably the first, again called attention to the network of crystal needles which develop in a porcelain body at high temperatures. It is probable that this condition offers an explanation of the ability of a porcelain body to resist thermal changes. A body which contains enough fusible, glassy material to produce density at a low temperature develops a glassy structure with the consequent brittleness. A body in which the fusible ingredient is so small in amount that high temperatures are not only possible but imperative are enabled by the intensity of the fire to so rearrange themselves in new combinations that the tough, interlacing crystals form a highly resistant bond.

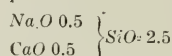
The glaze owes its ability to withstand chemical and thermal action to the same high temperature. A comparison of the composition of a hard porcelain glaze with that of lime-soda glass will serve to emphasize this point. The glaze as already given is, in ceramic expression:



or in percentage:

Silica	78
Alumina	12
Lime	6
Potash	4

The glass corresponds to:



or in percentage:

Silica	71
Lime	14
Soda	15

The high content of the alumina in the glaze is rendered possible by the intense fire while the low alkali content reduces the vulnerable point of the compound to the minimum.

In the laboratories of the State School of Ceramics at Alfred several studies of chemical porcelain have been made and numerous porcelains have been tested. The body of which the location on the triaxial diagram (Fig. 1) has already been given as consisting of 80 per cent clay, 10 per cent quartz and 10 per cent feldspar has been found to be equal to the German porcelains in behavior. The thermal test was made in the following manner which has been adopted as a standard.

The piece to be tested is inclosed in a fire-clay receptacle and exposed to the direct flame of a Meker or other suitable burner until the whole piece glows to a bright red. It is then quickly removed to a support close by and a blast of cold air is directed against one side. When cool the piece is reheated and again cooled. Any sample of porcelain which will withstand ten successive treatments without fracture is adjudged perfect. At the same time note is taken of any adhesion of the porcelain to the triangle upon which it rests. The hardest glaze shows no attachment whatever, and, of course, the softer glazes adhere, sometimes quite strongly. Some domestic porcelains have broken on the first or second heating and in at least one case the fragments clung to each other in a viscous string held together by the softened glaze.

In the case of the special mixture mentioned the pieces were first tested in the unglazed condition having been burned to the maturing point, cone 16, without glazing. Those pieces which stood the ten heatings and coolings perfectly were then glazed and burned a second time to cone 16. The test on the glazed pieces was then carried out and for the second time these porcelains made a perfect score. To ascertain the deformation point of the porcelain body small strips are cut from wares of different make. These strips, one inch high and a quarter of an inch wide at the base, are imbedded in plastic clay so as to stand erect. With the strips are set small cones of known softening point. When the deformation point of a body is reached the strip begins to bend and as the cones bend likewise in regular order an accurate comparison can be made.

The best porcelains begin to soften at cone 25 (1650 deg.) and the laboratory porcelain already discussed stands up a little better than Meissen and Berlin. The American porcelains, so far tested, begin to soften at

*A section magnified 300 diameters was shown by the author at the meeting. See Transactions Amer. Ceramic Society, vol. 18, p. 411, Fig. 12.

cone 15. At the same time the glaze on these wares rolls up into a bubbling wave while a true cone 16 glaze remains smooth.

Other tests were made by evaporating strong acids and alkalis to dryness and it was found that the glaze resisted attack fully as well as the German product. Acids scarcely attack these glazes at all, but no porcelain glaze is entirely resistant to alkaline attack.

It may be stated, therefore, that the production of perfectly satisfactory chemical porcelain is entirely possible if the established conditions be observed.

There remains now to consider the practicability of the American manufacture of chemical porcelains. The fact that such porcelains are being made would seem to prove this point and the reason why the wares have not hitherto proved to be of the best quality is not easy to understand. It has been found true that the American capitalist prefers to trust to the manufacturing experience of some empirical worker rather than to enlist the services of a technically trained man. The fact is that the output of chemical porcelain is not large enough to warrant the erection of a plant for this sole purpose, and it has been thought that the ware could be manufactured as a side line, using the appliances and the kilns already established. The special qualities demanded and the only methods by which these qualities can be secured have not been understood. There is probably not a kiln in this country fired as high as cone 16, which is the requirement, and to make the necessary adjustments in firebrick and refractory accessories presents serious difficulties to those who are accustomed to think in terms of cone 10.

Capital is timid and is accustomed to look out for bad weather ahead. It is feared that on the return of peace in Europe the American market will be again supplied with German porcelains. Inasmuch as a large proportion of these wares is imported duty-free it is not possible to erect a tariff barrier against them and anyone who invests his money in the manufacture is apt to lose it. This attitude more than any other is responsible for the reluctance of manufacturers to make the venture.

Certain wares have been advertised as equal to any in the world, but they have failed to withstand the tests imposed. Other wares prove satisfactory under one test and fail in another. It almost seems as though the persons responsible for the production of these wares were trying to obtain workable results without undergoing the expense of manufacturing the real thing. It must be acknowledged, on the other hand, that in view of the high rate of wages here and of the duty-free importation it will be difficult to compete with Europe.

Perhaps it may be thought that the tests which have been described are too severe. Severe they undoubtedly are. They were devised to exhibit the qualities of the best wares. Berlin, Bavarian, Copenhagen and Meissen stand up under the strain. No domestic porcelain tested so far stands up perfectly, though not all are equally weak.

There is no secret about chemical porcelain. Anyone who is generally skilled in pottery processes and who will take advantage of published information can produce it successfully, but to manufacture it economically and without undue loss there must be an infinite attention to detail and the exercise of unlimited patience.

N. Y. State School of Clay-Working and Ceramics,
Alfred University, Alfred, N. Y.

New German Scholarships in Chemistry.—The Liebig Scholarship Society has recently been formed in Germany for the purpose of aiding German chemical students, after their examinations, to proceed with their studies by working as assistants in the technical high schools. The society at its start had a sum of over 1,000,000 marks donated by the German industries.

Synopsis of Recent Metallurgical and Chemical Literature

An Improved Phosphoroscope.—In the *General Electric Review* for March, 1917, W. S. ANDREWS describes a phosphoroscope which he has developed for determining the fluorescence and phosphorescence of various compounds. The instrument operates by subjecting the object to be tested to the action of ultra-violet rays at short intervals and then exposing the object to the eye during the intermissions, while the exciting rays are cut off, the substance being otherwise in a lightproof chamber. The radiations are produced by means of high-tension disruptive sparks between iron points. By this instrument luminescence can be seen even when its period of afterglow is very short, i.e., what is termed fluorescence as distinguished from phosphorescence where the bodies show luminescence for a considerable period of time after the exciting medium has ceased to act.

Solvent Recovery in Rubber Industry.—In discussing rubber solvents in the *India Rubber World* for March 1, 1917, LOTHAR E. WEBER has the following to say in regard to solvent recovery: "Many attempts have been made to recover or partially recover the gasoline used in certain branches of the rubber industry, notably in the spreading operation. The volume of gasoline in a spreading plant vaporized in the course of a month's operation reaches staggering figures and it is only natural that the recovery of the solvent should have been given serious thought. While theoretically the recovery of gasoline from the spreading operation is a simple matter, the practical difficulties and cost of equipment have so far stood in the way of its applicability. In this connection it is not generally recognized that even if all the gasoline which is vaporized in the spreading room were successfully condensed, the resulting material would have properties differing materially from those of the original gasoline. Owing to the relatively low initial boiling points of gasoline, considerable losses take place during the churning operation; so much so, that if only the gasoline which is vaporized in the spreading room were condensed, its boiling points would be very much higher than those of the original gasoline. The recovery process, in order to make it complete, would have to be extended to the churn room. It can readily be seen, therefore, that the size and cost of equipment of such a complete recovery plant would be high. Nevertheless, there is every reason to expect that a recovery plant would be a good investment if the purely mechanical and engineering difficulties are solved." In commenting on the subject an editorial in the same issue gives the following data: "Most of the solvent mechanisms are either German or English in origin, and were designed for the great proofing establishments abroad. The Weber-Frankenburg, Vincent, Heinzerling and Spendle are the best known. While differing in many details, they do the work in much the same way. In a word, the fabric, as soon as it is proofed, enters a closed chamber, heat volatilizes the solvent, which is carried against cold surfaces, condensing it. Dripping from these surfaces, it is collected in tanks, often in water, drawn off and stored for re-use. The whole apparatus is simple and one that any chemical engineer can construct without difficulty."

Steel Foundry Sand.—That the problem of sand for the steel foundry has for a long time been considered a very important one is evidenced by the tremendous amount of literature available on the subject. The Tropenas Converter Company, in putting steel foundries of its process in operation for customers, was confronted with this sand problem several years ago,

and worked out a solution satisfactory to its engineers. An article on the subject is published in the company's bulletin *Steel Castings* for February, 1917. The authors are G. MUNTZ and E. ROUBIEU. They state that molding sand must be plastic, non-yielding, permeable to gases, capable of resisting high temperatures readily, and after serving its purpose must be easily destroyed. Furthermore, if any material answers all these conditions, its cost will have to be considered, in order to ascertain whether the advantages expected from its use are not to be secured at prohibitive expense. The various particles of silica do not adhere to each other naturally, thus an agglomerating medium will have to be called upon, if the above qualities of silica are to be taken advantage of. Clays have been chosen to agglomerate silica, because they are themselves refractory and can be found most anywhere; some have no plasticity and are, therefore, of no value to cement the silica particles, while others, for some reasons yet unknown, will form with pure silica, a plastic compound which is most suitable as a molding medium. There are other refractory materials possessing a much higher melting point than silica, but on various accounts are not used for molding. Thus, certain clays, such as the Kaolins, fuse at temperatures above those usually encountered in the steel foundry, but molds made of these would have to be dried thoroughly in order to be non-yielding, and in drying would shrink to such an extent and so irregularly that trueness to pattern would be almost impossible to preserve. Besides, permeability to gases would be almost nil, and destruction of the molds, after serving their purpose, would be most difficult. Either magnesia, lime or alumina is more refractory than silica, but not as widely distributed, and all lack some of the qualities indispensable to molding media. It seems then that sand, composed of silica, clay matter and their inherent impurities, is the only material we can use for molding purposes. The authors state that in the steel foundry clay is the necessary evil, as it is the carrier of the fluxes which will attack the almost pure silica of sand. Sands as provided by nature are usually round grained, and, if meeting the chemical requirements, represent the only class that should be used in the steel foundry. The conclusion is reached, quite at variance with usual practice, that sand must be relatively coarser to produce small castings than to turn out large ones. Ideal foundry sand is defined as an agglomeration of spherical particles of silica, each covered with as thin a coating of clay as can be applied on them. Clay is the enemy, it fuses at high temperatures, on account of the impurities it carries, and because of its very fine texture. The coating of clay that each particle of silica is to receive should then be reduced to a minimum. Air floated clay will average from 95 to 98 per cent fineness through a No. 200 sieve, and it is useless to state that if properly handled this material will be ideal for use in connection with such silica sands as are almost devoid of bond. To mix the round-grained, sharp silica sand with air-floated clay, the old pan grinder is yet the most efficient machine, due to the rubbing effect. The best sand, if not properly armored with nails, where the washing action of molten metal is most intense, will frit, causing scales on the one hand, and sand spots wherever the fritted material will be carried to portions where it cannot escape. Extensive areas, such as copes overhanging large bodies of metal, will often cave in if they are not properly armored.

Smoke Abatement.—In the Proceedings of The Engineers Society of Western Pennsylvania, OSBORN MONNETT of the American Radiator Company presents the results of many years of experience in the prevention

of smoke. The author was formerly chief smoke inspector of Chicago and in investigating the smoke problem in that city it was found that draft was the most important consideration. From a long series of investigations covering some thousand boiler settings, a curve was developed which gives the draft needed for different rates of combustion. The rule is that 0.01 in. of draft is needed over the fire per pound of coal burned per square foot of grate surface per hour. The limit rate of successful smokeless operation for hand-fired units is about 28 lb. of coal per square foot of grate surface per hour. Above this point reliance is placed on mechanical stokers. The rate of combustion is fixed first in any plant by the load. When this is known, the ratio of grate surface to heating surface is fixed, and these two factors decide the rate of combustion. The curve is then used to determine the draft requirement. In hand-fired furnaces by firing from the top and covering the clean grates with green coal to a depth of 4 or 5 inches, and then building a fire at the bridge wall with kindling or live coals, it is possible to get up steam without violating the smoke ordinance. In cleaning fires, if one side is cleaned out and the grates covered with green coal and then red hot coal thrown on top of the green coal, it is possible to clean a fire without smoking.

Recent Metallurgical and Chemical Patents

Alloys

Alloying of Manganese with Brass and Bronze.—A method of alloying manganese with brass and bronze is patented by Dr. HANS GOLDSCHMIDT and Dr. OTTO WEIL of Essen-on-Ruhr, Germany. The American patent is assigned to the Goldschmidt Thermit Company of New York. Manganese alone is added to brass and bronze baths with difficulty. These difficulties are partly overcome by employing a manganese-copper alloy, but if for making this alloy phosphor-copper is used instead of copper, the components alloy in a shorter time and at a much lower temperature. It is impossible to cast alloys of a high melting point with more than 25 per cent of phosphorus because of the evaporation. The minimum percentage is about 5 per cent phosphorus. The manganese varies between 30 and 50 per cent. The addition of these alloys is stated to greatly improve the quality of the brass and bronze (1,214,539, Feb. 6, 1917).

Brazing Material.—Alloys for brazing electrical connections are the subject of a patent of TRUMAN S. FULLER of Schenectady, N. Y. The patent is assigned to the General Electric Company. For brazing in locomotive armature windings induction motors, etc., it is stated to be necessary that the brazing metal should have a melting point high enough to prevent its melting during brazing and also low enough to allow of melting it for repairing the brazed parts. Other conditions are that the metal should be malleable and tenacious enough to be rolled in a foil and must alloy readily with the metals to be brazed. Alloys suitable for these purposes consist of silver and cadmium, the percentage of silver running from 57 to 65 per cent. Small amounts of other brazing metals, such as copper, are permissible, but readily oxidizable metals such as aluminium must be excluded. The alloy may be prepared by melting silver in a suitable crucible in a hydrogen atmosphere and then adding cadmium in stick form, preferably, somewhat in excess of the desired proportions, as some of the cadmium is volatilized. Instead of pure silver, sterling silver containing about 92.5 per cent silver, and 7.5 per cent copper may be used. Preferably 62.5 per

cent sterling silver and 37.5 per cent cadmium, which results in an alloy of 57.8 per cent silver, 37.5 per cent cadmium and 4.7 per cent copper. This alloy has a melting point of about 750 deg. C. (1,125,138, Feb. 6, 1917).

Alkali Metals and Cyanides

Production of Alkali Metals.—A method of producing metallic sodium or other alkali metal, by electrolysis of molten alkali chloride under a certain amount of pressure is patented by ROBT. J. MCNITT of Niagara Falls, N. Y. The patent is assigned to the Roessler & Hasslacher Chemical Company of New York. A cross-section of the furnace is shown in Fig. 1. The furnace has a graphite anode *A*, joined to conductors *B*. The cathode *C*, is joined to the conductor *D* at the bottom of the furnace. The total height of the furnace is quite large as compared with the reaction zone between the electrodes. The furnace is filled with sodium chloride to the level shown through the opening *Q*. The height of this column should be such that a pressure of about 1 lb. per square inch is exerted in the zone of electrolysis. When heated up by the current the sodium chloride becomes molten and metallic sodium is formed at the cathode and chlorine at the anode. A diaphragm *K* extending from the lower edge of the bell *Z* to the lower edge of cathode *C* separates the anode from the cathode compartment. As the sodium is formed it rises in the bell due to the difference in specific gravity between the two liquids. As a column of sufficient height is reached the sodium will flow through pipe *N* to container *O* (1,214,808, Feb. 6, 1917).

Manufacture of Cyanides.—A process of making cyanide by the combination of alkali metal vapor, nitrogen and charcoal is patented by HANS FOERSTERLING and HERBERT PHILIPP of Perth Amboy, N. J. The

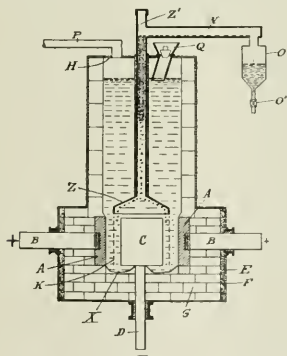


FIG. 1—CROSS SECTION OF ALKALI METAL FURNACE

patent is assigned to the Roessler & Hasslacher Chemical Company of New York. In referring to previous work the patent states that Acker in U. S. patent 914,100 disclosed a process for making cyanogen compounds by electrolyzing a molten compound of a metal with the cathode metal, removing the alloy from the electrolytic cell and reacting on the alloyed metal with nitrogen and carbon. The method described in the present patent differs from Acker's method in that the volatile metal is first separated from the cathode metal and then brought into contact with the nitrogen and carbon. The method of working this process is shown in Fig. 2. The electrolytic chamber is shown at 1, and the electrolyte at 9. The anodes are shown at 7 and the molten cathode at 8. The electrolyte is sodium chloride and

the cathode is molten lead for producing sodium cyanide. A partition 3, having an opening 4 at its right end, connects by means of the seal 5 with the furnace chamber 2, which is heated by a burner 11. In operation the electrolysis furnishes a sodium-lead alloy which passes through the seal 5 into the furnace chamber 2. Here nitrogen is blown through tube 10 and the sodium distills from the alloy and is carried together with the nitrogen over to chamber 15, filled with charcoal, where

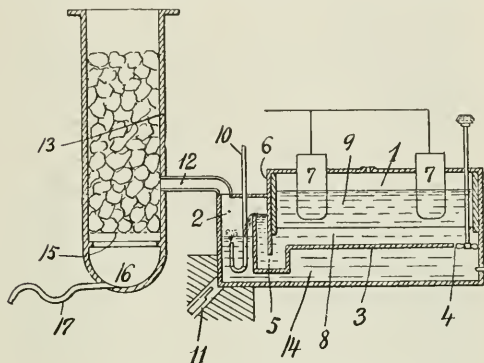


FIG. 2—DIAGRAM OF CYANIDE PROCESS

the cyanide forming reaction takes place. The impoverished alloy flows back through 14 and up through 4. Thus the lead forms a complete cycle and is not used up (1,214,770, Feb. 6, 1917).

Oxygen and Hydrogen

Electrolytic Oxygen and Hydrogen Generator.—An electrolytic hydrogen and oxygen generator with cobalt as the active anode element and iron as the cathode is patented by ISAAC H. LEVIN of New York, N. Y. The generator unit consists of a rectangular thin iron plate casing of small height, long and narrow. Any number of these may be joined together to form a complete generator. The iron casing is divided into two parts by an asbestos diaphragm, suspended from an impermeable partition which reaches about one-fourth of the way down into the cell from the top. An electrode is placed in each compartment formed by the diaphragm. The partition in the upper part of the cell prevents the combination of oxygen and hydrogen after the same have been generated and have risen separately to the top of the cell, being prevented from mixing by the diaphragm. Suitable means are provided for carrying away the gases, filling the generators with electrolyte, etc. The anode is made of iron, electroplated with a thin film of cobalt, and the cathode is of iron, preferably electrolytic. The electrodes are given a previous treatment by making them the anode in a solution of a salt of the active surface metal, and electrolyzing for a brief period. This is claimed to give greater efficiency in operation (1,214,934, Feb. 6, 1917).

Iron and Steel

Refining and Deoxidizing Iron and Steel Scrap.—EDWARD H. SCHWARTZ of Chicago, Ill., patents a process of producing high-grade material from scrap by melting with carbon-steel scrap a proper proportion of silico-spiegel or manganese steel scrap, with or without the addition of pig iron of suitable silicon content. Preliminary smelting may be carried out in a cupola on a bed of coke or coal and then the molten product transferred to an electric, open-hearth or reverberatory fur-

nace or a converter. In treating carbon steel for final electric-furnace treatment about 95 per cent steel scrap and 5 per cent spiegeleisen are used in the cupola charge. In making manganese steel a mixture of 30 per cent manganese-steel scrap, 50 per cent carbon-steel scrap and 20 per cent high-silicon pig iron is used when converter treatment is to follow cupola melting. The process may also be used for the manufacture of semi-steel, gray iron and white iron, using in each case quite large percentages of scrap. The high grade of product obtained is stated to be due to the deoxidizing and refining action of the manganese. The spiegel scrap also exerts a desulfurizing action on the carbon steel scrap when melting in the cupola, and by using limestone as flux more or less phosphorus is eliminated (1,215,065. Feb. 6, 1917).

Miscellaneous Apparatus

Automatic Extraction Apparatus.—An apparatus for the automatic extraction of values from solid substances is patented by RICHARD L. OGDEN of Rahway, N. J. The material to be treated is suitably sized and placed on a colander just beneath the cover of a tank. By an arrangement of pressure tanks and regulators the extracting solution from another tank is sprinkled over the material and is automatically returned to the tank and resprinkled over the material again until the extraction is completed. The necessary air pressure and suction are provided by the raising and lowering of water in a vessel (1,215,182, Feb. 6, 1917).

Explosions Due to Presence of Hydrogen in Electrolytic Oxygen

The attention of the Bureau of Mines, Department of the Interior, has recently been directed to a series of explosions of oxygen made by the electrolytic process in which life has been lost, as a result of hydrogen being mixed with oxygen. The first of these explosions occurred in Cincinnati, the coroner's jury calling attention to the fact that there were no specifications for the purity of oxygen and recommended to Col. B. W. Dunn of the Bureau of Explosives, which bureau publishes regulations regarding the transportation of explosive substances throughout the country, suggesting that that bureau make investigations.

As the Bureau of Explosives did not have any facilities for making such tests Colonel Dunn referred the inquiry to the Bureau of Mines with the request that it investigate the question. The problem is important in view of the extensive use of oxygen for welding and cutting purposes.

Active testing was begun and the preliminary stages of the investigation were recently completed. In the meantime, there have been many inquiries for information and the bureau has explained that a printed report will be issued at the earliest possible moment. According to George S. Rice, chief mining engineer of the bureau, the principal findings of the bureau are that "strictly speaking there is no spontaneous combustion, but in all cases where sufficient data have been obtained, the oxygen has been used in conjunction with a torch for welding or cutting, and the flame has flashed back through the mixture. It is possible that ignition may occur by a jet of oxygen playing on a carbonaceous material under certain special conditions; nevertheless, these conditions are most unusual as in many experimental tests made by the bureau the jet could not be so arranged as to cause ignition, although there was a rise of temperature at a certain point and cooling due to expansion at a point beyond.

"In all cases, however, the real danger is in the hydro-

gen getting into the oxygen, and it has been found that this is due to improper design in the manufacturing apparatus, i.e., the cells and electrical connections; to insufficient safeguards connected with the electric apparatus, the polarity suddenly and unexpectedly shifting; to the manufacture of oxygen without frequent analyses; and to incompetent or ignorant attendants. Unfortunately, certain makers of oxygen manufacturing apparatus have advertised that any laborer can take care of their apparatus. It is believed that the manufacture of electrolytic oxygen can be carried on in a manner to make it entirely safe. In fact, there has to be over 9 per cent of hydrogen with the oxygen to make an explosive mixture. Nevertheless, certain tanks from one batch caused three widely separated explosions in California, killing seven men in all, and an analysis of gas from a tank filled at the same time showed that it contained over 50 per cent of hydrogen."

Use of Rotary Kilns for Calcining Lime

By A. T. Wood

In the past few years a great deal of interest has been taken in the use of rotary kilns for calcining lime, due no doubt, to the many advantages of the rotary kiln over the vertical type.

Very little information is obtainable or published due, no doubt, to the fact that lime manufacturers who are now operating rotary kilns are fully acquainted with its many advantages and they are not desirous of letting information get out to the public as to its real value. They prefer to hold back the information as long as possible.

Following is a general description of a modern calcining plant, including all of the equipment, starting from the quarry to a finished product:

The capacity of the plant is a determining factor as to the proper size machines to be used in the process. Taking as a basis say a 1000 bbl. plant, or over, in twenty-four hours, the quarry should consist of steam shovel of the proper size for handling the proper amount of stone. The size dipper to be determined from quarry conditions, that is, as to how the stone lays and how it breaks under powder or dynamite. From the steam shovel the stone is discharged into side dump cars, usually from 4 to 10 yd. capacity. The cars being drawn to a central point by a locomotive where they are discharged into a large initial crusher. The type of crusher being the one preferable if the quarry conditions cal conditions of the quarry being a determining factor as to which of the three types is best suited, the roll crusher being the one preferable if the quarry conditions permit. After the material passes through the large initial crusher it is elevated to sizing screens, where the material is sized, the rejections passing to smaller crushers for re-crushing. This material is again elevated and sized. After the material is of proper size it is discharged into storage bins where it is available for feeding to rotary kilns.

While at this point the question of sizing material is a very important one, it is however, very easily disposed of. In certain sections of the United States, certain limestones, especially those found in the New England states, are of such a character that sizing is not an important factor. The stone has certain characteristics so that when exposed to temperatures around 650 deg. C. it disintegrates to a point where it is practically uniform in size. However, limestones found in Central and Western states are very hard and dense. This class of limestones, either calcium or magnesian, should be properly sized to secure best results.

From the storage bins where the material has already passed the sizing screens the limestone is fed by a positive feeder to the rotary kilns. The kilns are on a slight inclination, revolving at a very slow speed, similar to cement kilns, limestone gradually passing through and leaving the discharge end of the kiln in an oxide state, entering the rotary coolers which are also on a slight inclination where the oxide lime is cooled and from the coolers discharging on to conveyors where the material is conveyed to steel or concrete storage tanks. From the storage tanks the material is ready for shipment, either in bulk or placed in barrels or conveyed to hydrating plant, where it may be hydrated and made ready for shipment.

Kilns.—Rotary kilns may be secured from 2 ft. to 12 ft. in diameter and from 10 ft. to 210 ft. in length on two carrying mechanisms. The standard proportions of rotary kilns are $17\frac{1}{2}$ ft. of length per 1 ft. diameter. In some cases this limit may be exceeded. Rotary kilns are in all cases lined with fire brick. The hot zone or the discharge end is lined with 9-in. brick, while the upper or cool end contains 6-in. and 4-in. brick.

Coolers.—Coolers are similar to the kilns in appearance, but contain no lining. They are, however, fitted with lifters so as to lift the material dropping same through space where it has a chance to come in contact with the cool air which is passing through the cooler while being pre-heated for combustion.

Fuel.—Producer gas, natural gas, oil or pulverized coal may be used in rotary kilns for calcining lime. With the exception of pulverized coal any of the above fuels may be used for producing the highest grades of finishing lime, the choice being the one that is the cheapest to secure.

For producer gas work any good grade of bituminous gas coal may be used, the following analysis being one of excellent grade: Vol. matter, 34.78; carbon, 60.57; ash, 3.84; sulphur, 0.81; B.t.u., 14,590.

The average natural gas would have analysis as follows: CO_2 , 0.29; O, 0.30; C_2H_6 , 1.04; CO, 0.60; CH_4 , 93.57; H, 1.40; N, 2.80.

The average analysis of oil gas will be found as follows: CO_2 , 0.90; O, —; C_2H_6 , 17.40; CO, —; CH_4 , 58.30; H, 23.40; N, —.

The use of pulverized coal is not advisable where the highest grades of commercial lime are required. This is due to the fact that in pulverizing the coal there will always be found small particles which are not entirely pulverized which when blown into the burning zone of the kiln, being heavier and larger, do not immediately undergo complete combustion but drop to the bottom of the kiln, and mix with the product where it is carried along with the oxide of lime. These small specks of carbon or ash do not make their appearance until the oxide of lime is being used as hydrate or finishing plasters. At this point the ash or carbon which has been deposited, due to the use of pulverized fuel, appears in the hydrate or finishing plasters in black specks. The pulverized fuel, however, may be used equally as well as the other fuels except in the above case.

Power.—Power to operate rotary kilns when used for calcining lime may be either mechanical or electrical. An electrically driven plant has many advantages over the mechanically driven plant. Engines with the highest efficiency should be chosen. Motors of ample power for continuous hard service should also be considered. Boilers of ample capacity for continuous operation, as well as a spare unit for emergency purposes due to continuous operation should also be considered.

Advantages.—The following advantages are claimed for the use of a rotary kiln for calcining lime: A more

uniform product is obtained. The fuel cost per ton of lime is decreased. The repair cost of linings per ton of lime manufactured is decreased. The output is increased. The labor costs are reduced. Quicker results are obtained. All classes of limestones or by-products may be calcined. Quarry spalls are done away with, also no draught troubles and back-fire troubles. The material is in better shape for hydrating purposes. The process is under absolute control at all times.

Milwaukee, Wis.

A New Rust-Proofing Material and Process

The most generally used methods for covering iron and steel with non-rusting metals are based on dipping the articles into molten baths of the protective metals. The best known are leading, tinning and galvanizing, as either lead, tin or zinc are used. In all such processes there is a very considerable loss of the coating metals due to the oxidizing of the molten metal bath.

In our Jan. 1, 1917, issue attention was called to a new coating process in an article by Henry Hess of Philadelphia, Pa. The process originated in Germany and utilizes finely divided zinc or other metals or alloys mixed with a liquid medium. This material, known as "epicassit," is applied cold with a brush and then heated slightly above the melting point of zinc. It is claimed that oxidation losses are avoided by the use of this material, and that the process may be carried out not only on an extensive manufacturing scale, but also on a job involving only a few square inches or the repair of a damaged coating.

The powdered metal, usually either tin, lead, zinc or their alloys, are mixed with a suitable fluxing carrier to the consistency of a smooth, creamy paint. This is evenly coated on the well cleaned article. Heat is then applied to melt the coat down. Details will vary with the nature of the article to be coated. The cold paint may be applied with the brush, just like ordinary paint, or the article may be dipped into the cold bath, or it may be drawn through it, or tumbled in it. The heat may be applied in whatever way is most convenient; the cold painted articles may be placed on shelves or on racks in an oven, more or less similar to an enameling oven; small articles may be placed in heated tumblers that are stationary, until the coating is melted down and are then tumbled to prevent sticking. Other articles are carried through a cold bath of the material on conveyors and discharged onto slightly inclined coarse sieve shakers where superfluous material is first shaken off and gathered again for re-use; in their further travel the articles pass through a heated zone in which the coating is melted down and sticking prevented by the shaking of the carrier; the final discharge is into water or a tumbler with polishing material, as sawdust, etc.

Instead of drawing wire through a hot bath, with its many incidental losses and inconveniences, the wire is drawn through a cold bath of "epicassit" or this is applied by rotating brushes or a spray; in its further progress the wire passes through an externally heated tube of uniform temperature and onto a reel, making the process continuous.

Tanks, etc., that are built up of leaded or galvanized sheets and are too large to be dipped are rustproofed where exposed by erecting machinery, such as punching, riveting, etc. In this case "epicassit" is locally applied with a brush and melted on with a suitable torch.

The process and product are covered by U. S. patents which have been acquired by Mr. Hess, Witherspoon Building, Philadelphia, Pa., and licenses are granted to use the process. The material itself is handled by Hess & Son, 1033 Chestnut Street, Philadelphia.

A Stoneware Atomizing Nozzle for Acid Chambers

There are a number of plants manufacturing sulphuric acid which inject water, instead of steam, into their chambers. This method has been found particularly beneficial during the hot summer months when steam of course would not condense readily, whereas when operating with water sprays, the water is atomized to a mist, and as the chambers are usually located in a building, and enclosed otherwise in themselves, there is little likelihood of the freezing question coming up even in the Northern States, although most of the plants are located in the Southern States.

The injection of water into the chambers in a mist-like form or fog, is done simply by putting the water

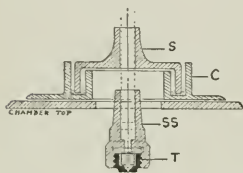


FIG. 1—ARRANGEMENT OF NOZZLE

under pressure and distributing it in the chambers at the top. The arrangement of connecting and supporting the spray nozzle is shown in Fig. 1.

Most plants are equipped with either glass or platinum sprays, and in the case of glass sprays there is considerable breakage, due to sudden change in temperature, and the platinum sprays are very costly, especially at present. The Monarch Manufacturing Works, 1910 North Camac Street, Philadelphia, Pa., have taken up the manufacture of a patented nozzle and are making it of stoneware—the whole of the tip (shown at T in Fig. 1), being made of stoneware. They claim that this nozzle will fit directly into the usual lead sockets (SS Fig. 1) in which at present either glass or platinum are used, thereby not necessitating the replacement of the lead socket SS as well; also that due to this new construction, which has been patented, they are able to operate with one-half the pressure at which such atomizing nozzles are usually operated, and give equal capacity and the finest possible atomization of the water, with capacities ranging from 2.5 gallons of water per hour per nozzle up to about 20 gallons per hour.

From Fig. 1 it will be seen that the threaded stoneware part T, has an inner part which fits loosely into the threaded part. Water is prevented from passing around the outside of the inner part by means of a rubber washer as shown, thereby necessitating that the water travel directly into the canal in the inner part, which inner part is made with a projection extending up into the outer stoneware part. Holes are drilled into this neck at such an angle as to give the water a centrifugal motion, thereby enabling it to emit from the orifice of the outer stoneware part in an atomized form. The reason given for this nozzle operating at such low pressures is because the liquid has such a comparatively small length of travel through a restricted area.



FIG. 2—NOZZLE PARTS

The inner stoneware part does not move when the nozzle is in operation—the water simply passes out the orifices which are drilled at a predetermined angle as above explained.

Cleaning of these tips, when required, is made easy because immediately the outer threaded tip is removed from the lead socket, the inner stoneware part, being loose-fitting, will drop out.

This nozzle is also claimed by the manufacturers to retain its spraying qualities indefinitely, because both parts are made of an exceptionally hard close-grained stoneware, wear on which is practically nil. The shoulders prevent of its being reinserted too far towards the orifice of the outer part when the inner part is removed for cleaning. It is claimed, therefore, that the nozzle must always give identically the same spray as originally, regardless of the number of times the inner part is removed for cleaning. Nozzles which require the inner part made of lead, however, necessarily produce a different quality spray every time the inner part is removed, because, due to its construction, must be hammered in sufficiently tight to make a seal around the threads of the inner part (spiral) the full length of the outer threaded tip, and the water travelling this full length through a restricted area, is said to be the cause for requiring double the operating pressure.

Growth of Mellon Institute.—The first Industrial Fellowship at the University of Pittsburgh was established in March, 1911, by a baking company in the Department of Industrial Research, now known as the Mellon Institute of the University of Pittsburgh. In the six years which have elapsed sixty-four distinct concerns have endowed some 147 one-year Industrial Fellowships for the study of problems in which they were interested. The following table shows the number of Industrial Fellowships which have been founded from March to March of each year—1911 to 1917; the number of researchers or Industrial Fellows as they are called, who have been employed on these Fellowships, and the total amounts of money contributed for their maintenance by industrial concerns:

March to March	Number of Fellowships	Number of Fellows	Amounts Contributed
1911-1912.....	14	24	\$29,700
1912-1913.....	16	30	54,300
1913-1914.....	21	37	78,400
1914-1915.....	21	32	61,200
1915-1916.....	36	63	126,800
1916-1917.....	42	65	149,100

The total amount of money contributed by industrial firms to the institute for the six years ending March 1, 1917, was \$509,500. In addition to this sum, over \$350,000 was expended by these concerns in the construction of experimental plants. During the six years the institute itself expended about \$230,000 in taking care of the overhead expenses in connection with the operation of the Fellowships. Besides this amount the building and permanent equipment of the institute, which make it the most complete and modern industrial experiment station in the country, represent an investment of about \$350,000. Apart from the fact that the results obtained under the Industrial Fellowship system at the Mellon Institute have justified the expenditure of the sums of money mentioned above, it is interesting to note that the success of the Fellowships has encouraged manufacturing organizations to establish well-equipped research departments of their own. Then, too, it has given a new impetus to industrial research work on the part of institutions of learning both in this country and abroad. Through the Industrial Fellowship system, these institutions have found a way to forward the progress of industry and at the same time add to the sum of human knowledge.

Detroit Meeting of American Electrochemical Society

The thirty-first general meeting of the American Electrochemical Society will be held in Detroit, Mich., from Wednesday, May 2, to Saturday, May 5, inclusive. The following attractive program, subject to revision, has been arranged:

Wednesday, May 2—Afternoon: Official visits to automobile plants—Dodge, Packard, Hudson.

Wednesday, May 2—Evening: "Get together" subscription roadhouse dinner, members of American Electrochemical Society, Society Automobile Engineers, A. I. E. E., Detroit Engineering Society.

Thursday, May 3—Morning session: Electric Steel—its manufacture, uses, advantages and heat treatment; abrasives; ferro-alloys.

Thursday, May 3—Afternoon session: General Electrochemical papers.

Thursday, May 3—Evening: Smoker.

Friday, May 4—Morning session: Melting of non-ferrous metals; also various low temperature electro-thermic processes.

Friday, May 4—Afternoon: Visits—electric steel plants, powerhouses, etc. Lake Shore drive.

Friday, May 4—Evening: Presidential address; address by Mr. Alex Dow.

Saturday, May 5—Morning session: Electro-deposition of metals; rust prevention. Miscellaneous papers.

Arrangements can be made for groups to visit the Ford or other plants, at any time, by application to the entertainment committee.

Ladies entertainment—Thursday, May 3—Afternoon: Lake Shore drive; tea at Belle Isle or Detroit Athletic Club; on Thursday, May 3, evening, theatre party, and on Friday, May 4, afternoon, drive through Bloomfield Hills, tea at Bloomfield Hills Golf Club. Conveyances and guides for shopping trips at any time by application to the entertainment committee.

The program of papers will be published in our next issue.

New Engineering Society Organized in Southwest

At a convention held in El Paso, Tex., on March 8, 9 and 10 the Southwestern Society of Engineers was organized with more than one hundred charter members. Membership is open to civil, mechanical, mining, electrical or chemical engineers, or architects or other persons belonging to a technical profession, who are not less than twenty-seven years of age, and who have been in active practice of their profession for at least six years. Provision is also made for associated, honorary and affiliated members.

The great distance from centers of population makes it difficult for southwestern engineers to attend meetings of the national engineering organizations, so it is believed that the new society will fill a real need. It is planned to hold at least two conventions of the society each year for the reading and discussion of professional papers and for social intercourse.

At the first convention the following papers were read and discussed:

"The Purpose of Engineering Education," by Dean G. M. Butler, College of Mines and Engineering, University of Arizona.

"Some Lessons Taught the Mining Industry of the Southwest by Present Activities and Prices," by Gerald Sherman, Mine Superintendent of the Copper Queen Consolidated Mining Company, Bisbee, Ariz.

"Modern Highways and the Dividends They Pay," by

J. L. Campbell, chief engineer of the E. P. & S. W. R. R. "Engineering and National Defense," by Lieut. Col. M. L. Walker, Corps of Engineers, U. S. Army, chief engineer of the recent punitive expedition into Mexico.

The officers of the society are:

President, Dean A. F. Barnes, School of Engineering, New Mexico College of Agriculture and Mechanic Arts.

Vice-president for two-year term, Dean G. M. Butler, College of Mines and Engineering, University of Arizona.

Vice-president for one-year term, Dean S. H. Worrell, Texas College of Mines.

Secretary, Forrest E. Baker, El Paso, Tex.

Treasurer, R. W. Goddard, Professor Electrical Engineering, N. M. College of Agriculture and Mechanic Arts.

Director for three-year term, S. O. Andros, Albuquerque, N. M.

Director for two-year term, J. N. Gladding, city engineer, El Paso, Tex.

Director for two-year term, D. B. Gillies, general manager Carrigan-McKinney & Company, Chihuahua.

Director for one-year term, J. C. Ryan, county engineer, Cochise County, Arizona.

Director for one-year term, W. E. Robertson, El Paso, Tex.

Kansas City Meeting of American Chemical Society

Active preparations for the Spring meeting of the American Chemical Society, which will be held in and around Kansas City, Mo., during the week of April 9 are being made by local committees of which the following are chairmen.

Executive.—W. A. Whitaker, Lawrence, Kan.

Finance.—R. Hirsch, Kansas City, Mo.

Reception and Registration.—L. E. Sayre, Lawrence, Kan.

Smoker.—G. H. Clay, Kansas City, Kan.

Banquet.—Roy Cross, Kansas City, Mo.

Publicity.—F. B. Dains, Lawrence, Kan.

Excursions.—C. F. Gustafson, Kansas City, Kan.

Entertainment of Ladies.—Mrs. F. B. Dains, Lawrence, Kan.

The headquarters will be at the Hotel Muehlebach, corner Twelfth and Broadway Streets. In addition to the regular general and divisional meetings, smoker and banquet, interesting excursions are being arranged to the following industrial plants: Packing houses, flour mills and other foodstuffs factories, zinc smelters, acids, cement, paper, soap and structural steel factories and a petroleum refinery. The University of Kansas at Lawrence will also be visited.

Personal

Prof. W. D. Bancroft has been selected by the American Electrochemical Society to represent electrochemistry on the Chemistry Committee of the National Research Council. The Board has also pledged the Society to co-operate with this committee in aiding the cause of electrochemical research in the country.

Dr. John H. Banks of the late firm of Ricketts & Banks, announces that his son, Harold P. Banks, has been taken into partnership. The address of the new firm of John H. Banks & Son will remain at 61 Broadway, New York.

Mr. Emile J. Bayle, assistant to the president of the Pfaunder Company, Rochester, N. Y., gave an address before the Rochester Engineering Society on March 2 on "Profit-Making Management."

Mr. C. Bramson, formerly chemist with the Provident Chemical Works is now connected with the Superior Phosphate Company, in Illinois.

Mr. C. F. Carrier, Jr., who was general superintendent of the Warner-Klipstein Chemical Company, during the construction and starting of their new plant at South Charleston, W. Va., has recently accepted a position as department manager and chemical engineer with the Rollin Chemical Company, Inc., who are the largest manufacturers of barium chemicals in the United States. He will have charge of the chemical engineering connected with extensive additions which are being made to their plant at Charleston, W. Va.

Prof. W. J. Crook has resigned from the South Dakota State School of Mines to re-enter the employ of the Pacific Coast Steel Company at South San Francisco. He will take up his duties there about April 1. He was chief chemist at these works prior to his appointment at the mining school in 1913.

Mr. Samuel F. Eldridge, formerly connected with the Columbus Iron & Steel Company, Columbus, Ohio, as engineer, has been appointed special agent of the American Rolling Mill Company, Middleton, Ohio, owing to the consolidation of the above companies under the latter name.

Mr. Arthur I. Jacobs, who for seventeen years was in charge of the water and electric light departments of the city of St. Louis, has joined the research department of the Powdered Coal Engineering and Equipment Company of Chicago.

Mr. F. A. Kennedy has resigned as a member of the instructing staff of the mining and metallurgy department of the University of Wisconsin, and is now consulting engineer with John A. Savage, Duluth, Minn.

Mr. Charles Of recently returned from Cuba, where he was in charge of the mining operations of the Davison Chemical Company.

Mr. Louis S. Potsdamer has come to New York from Sweetwater, Tenn., to take up new duties with Messrs. Toch Bros. He was acting treasurer of the Durex Chemical Works at Sweetwater.

Mr. J. L. Replogle has been elected president of the American Vanadium Company, Pittsburgh, Pa., succeeding James J. Flannery, who becomes chairman of the Board of Directors. Mr. Replogle was formerly vice-president and general sales manager.

Mr. Kirby Thomas has been spending several weeks in Brazil. He is expected to return in a short time.

Mr. Howard F. Weiss, whose resignation as director of the Forest Products Laboratory of the United States Forest Service takes effect April 1, will become associated with the C. F. Burgess Laboratories, Madison, Wis., for consulting, experimental and development work in chemical engineering lines. Mr. Weiss will have direction of the division relating to wood products.

CURRENT MARKET REPORTS

The Iron and Steel Market

The steel market in the past fortnight has presented the appearance of having been sold to a standstill, the turnover being confined very largely to the making of contracts with regular mill customers for additional delivery periods. There was increased disposition to buy, on the part of some consumers, by reason of fear that steel furnished the United States Government on rush orders would reduce deliveries to the regular domestic trade.

The volume of government business placed cannot be estimated, but it is known that a number of rush orders have been placed, and in many instances rolling was undertaken at once, previously arranged rolling schedules being dropped when the authorities expressed a desire that the steel be furnished at the earliest possible time.

While the requirements of the government are large in its program of preparing for war, the relation between the tonnage and the total capacity of the industry may easily be overrated. The steel productive capacity of all the present belligerents, at the time the war started, was approximately 43,000,000 tons, measured in steel ingots, while the United States now has a capacity of approximately 45,000,000 tons, so that what is a large tonnage for the belligerents on either side, for war purposes, is a relatively small tonnage for the United States.

While the virtual entrance of the United States into the war has made steel scarcer and the steel market stronger, the prospects for a continuance of the present high prices for steel are not thereby prolonged, for there is the offset that the participation of the United States may have a moral effect before it has much physical effect, and operate to bring the war to an earlier conclusion than would otherwise have been the case. Finished steel products, for shipment at mill convenience, are held at nearly three times the prices, on an average, that obtained in December, 1914, when the market was at its lowest level since 1898. The excess over the low level is almost four times as great as obtained in 1907, when steel prices were at the highest level attained between 1902 and 1916. It is commonly held in business circles that the end of the war will bring a readjustment in all commodity values. The non-ferrous metals are expected to discount the end of the war, and indeed quite recently it was maintained in some quarters that signs of a tendency to discount the war's end were already apparent. The steel mills, however, may find it possible to maintain prices for a time, as they have learned to resist price declines, acting independently and without the meetings that have come to be considered illegal. It must be recognized also that the depreciation of the dollar is not wholly temporary, and that relatively high commodity values are likely to rule for several years after the war.

There is certainly nothing like a consensus of opinion in the iron and steel trade as to what is likely to occur. The common view undoubtedly is that the war will not last beyond the present year, and yet there has been some buying of pig iron for delivery in the first half of 1918, at prices at least as high as have obtained for the second half of this year. This buying has occurred only as to certain districts, notably Virginia and Southern Ohio. There is much valley iron unsold for the second half of this year.

Pig iron prices have been advancing in all markets, an advance of a dollar a ton frequently occurring overnight. The averaging price is now approximately \$35 a ton at furnace, or very nearly three times the price two years ago, when the market was at its lowest point since 1904.

Finished-steel price advances in the past fortnight have been relatively unimportant, the very large advances in the fore part of March having apparently equalized with the influences at work. Billets are higher, at \$70 to \$75.

Transportation conditions have been improving, although slowly, and production increases slowly, while shipments have increased somewhat more rapidly, and mills are now making inroads in the stocks accumulated during the winter.

Non-Ferrous Metal Market

Saturday, March 24.—The copper market has been dull but has remained firm. Tin has advanced following an advance abroad, while spelter remains virtually unchanged. Lead is also unchanged. Antimony is scarce and has again advanced. Silver has taken a slight drop.

Copper.—The situation in this market has been very dull. Offerings were freer for second quarter about the middle of March. A strike at the Nichols Copper Company's Laurel Hill refinery started on the 16th and lasted about a week. Shipments were curtailed during the strike. Some of the producers have offered to sell copper to the Government at half price, and over 45,000,000 lb. was taken at a little below 16 $\frac{3}{4}$ c.

Tin.—On the 15th there developed a strong demand for tin in London which advanced the market there and likewise here. From 53.25 on the 15th, Straits tin has risen to 56.25. Arrivals so far this month only total 1585 tons but there is considerable tin afloat. Banca tin is scarce but there has been some sales of No. 1 Chinese at 45c. for April delivery.

Lead.—The lead market has been quiet, and the trust price remains at 9.00 cents, New York, with independents asking 9.87 $\frac{1}{2}$.

Spelter.—This market has remained firm in spite of the continued poor consuming demand. The price remains virtually unchanged at 10.80 to 10.92 $\frac{1}{2}$ New York for spot.

Other Metals.—Antimony has been very scarce for spot deliveries. There has been little interest in futures. The price for spot jumped from 32.00c. to 34.00c. on the 20th. Silver has been gradually declining for some time and registered a decline from 73c. on March 15 to 72 $\frac{3}{4}$ on March 23. Aluminium remains at 58.00-60.00c. for No. 1 virgin metal. Magnesium is unchanged at 3.00-3.50; Electrolytic nickel is 0.55c.; cadmium 1.50; quicksilver 120.00; platinum, 105.00; cobalt, 1.70; and tungsten concentrates, 17.00-17.50 per unit.

Chemical Market

Coal Tar Products.—A good volume of business has been transacted during the past two weeks and the outlook from both the producing and selling viewpoint has been decidedly encouraging. Higher prices have as a rule been in force and the general tendency upon the part of manufacturers has been to hold stocks and make consumers pay the piper. *Benzol* and *Toluol* markets have moved in unison and manufacturers have been sitting tight and doling out comparatively small quantities and have been gunning for new business only in a few instances. A few stray cars of benzol have been offered from time to time and these generally reached a buyer quickly when the product measured up to standard specifications. Toluol has been even more firmly held than benzol and but few lots of surplus material have reached the market. *Xylol* is meeting with a wider demand but offerings are heavy and some manufacturers are quoting at a comparatively low figure. *Solvent naphthas* continue to press on the market but producers have been studying possibilities of new sources of consumption and it is stated that considerable quantities have now found their way into industries that have heretofore used petroleum products.

Aniline oil continues firm. Some of the former producers who dropped out when prices did not allow of a profit have inaugurated a new production but this so far does not appear to have overtaken the demand and there is still difficulty noted in securing stocks for immediate delivery.

The toluol derivatives have come in for special attention during the fortnight and *para toluidine* has been in brisk demand. Manufacturers of inks and dyes have

been in the market in a heavy and urgent way. Quotations for this intermediate have advanced sharply and at the moment of writing supplies are centered in one or two hands. *Ortho toluidine* has shared in a degree the firmness of para, but supplies have become more liberal. *Ortho* and *para nitrotoluol* have experienced a somewhat similar experience and the few producers report important inquiry.

Phenol continues to be the bête noire of the coal tar producers. Prices are low and stocks are more than abundant to answer any needs of the trade. Hopes appear to be centered in possible government buying but so far this has not materialized.

Diphenylamine has been subject to a very heavy demand from explosive manufacturers and offers are now greatly restricted. One of the leading producers has advanced his quotations about 20 per cent.

Glycerine has developed a general undertone of activity and considerable business has passed for both domestic and export account. The movement, of course, has been principally in dynamite grades although C. P. has met with a heavy consuming inquiry.

Arsenic has advanced sharply and Paris Green has been moved up in sympathy. This is a reflection of the usual seasonal demand. *Quicksilver* has been subject to an erratic movement. Spot stocks have been taken up quickly and quotations to arrive on rolling material have been established on a high level.

Caustic soda and *soda ash* are higher both on spot and contract. There is a very important inquiry noted for 1918 business and as a result of the freight congestion spot lots have not been obtainable at other than fancy prices from day to day. Manufacturers are well sold out for practically all nearby positions. *Bleaching powder* in contrast is off and there is not much demand.

In acids, the high grade *acetics* have been in active demand for foreign accounts and supplies are scarce. Orders for glacial have in some instances gone begging because of the impossibility of securing supplies for immediate shipment. *Nitric acid* which recently advanced sharply has moved somewhat slowly and some business has been taken quietly at reduced prices. The demand has been spasmodic. *Sulphuric acid* has been moving steadily into consumption at quietly firm prices. The high level upon which brimstone is quoted finds reflection in the brimstone acid situation. *Bichromates* are easier and consumers are inclined to hold off. *Borax* and *Epsom salts* have been in such scanty supply that many orders have remained unfilled.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET MARCH 23, 1917.

Acetic anhydride	lb.	\$1.75	—	\$1.85
Acetone drums	23	—	—	23 $\frac{1}{2}$
Acid, acetic, 28 per cent.	lb.	.04	—	.04 $\frac{1}{2}$
Acetic, 56 per cent.	lb.	.08	—	.09 $\frac{1}{2}$
Acetic, glacial, 99 $\frac{1}{2}$ per cent carboys.	lb.	.25	—	.27
Boric, crystals	lb.	.10 $\frac{1}{2}$	—	.11
Citric, crystals	lb.	.73	—	.73 $\frac{1}{2}$
Hydrochloric, commercial, 18 deg.	lb.	.01 $\frac{1}{2}$	—	.01 $\frac{1}{2}$
Hydrochloric, 20 deg.	lb.	.01 $\frac{1}{2}$	—	.01 $\frac{1}{2}$
Hydrochloric, C. P., conc., 22 deg.	lb.	.01 $\frac{1}{2}$	—	.01 $\frac{1}{2}$
Hydrofluoric, 50 per cent, in barrels	lb.	.04 $\frac{1}{2}$	—	.05
Lactic, 44 per cent.	lb.	.10 $\frac{1}{2}$	—	.12
Lactic, 22 per cent.	lb.	.05	—	.05 $\frac{1}{2}$
Nitric, 36 deg.	lb.	.05	—	.05 $\frac{1}{2}$
Nitric, 42 deg.	lb.	.06 $\frac{1}{2}$	—	.07
Oxalic, crystals	lb.	.45	—	.46
Phosphoric, 85 per cent.	lb.	.28	—	.30
Phoric	lb.	.70	—	.80
Pyrosulphic, resublimed	lb.	3.50	—	—
Sulphuric, 60 deg. (brimstone)	ton	18.00	—	20.00
Sulphuric, 66 deg.	ton	22.00	—	30.00
Sulphuric, oleum (Fuming), tank cars.	ton	34.00	—	35.00
Tannic, U. S. P. bulk	lb.	.45	—	.50
Tartaric, crystals	lb.	.83	—	.85
Alcohol, grain, 188 proof	gal.	2.62	—	2.64
Alcohol, wood, 95 per cent.	gal.	.90	—	.92
Alcohol, denatured, 150 proof	gal.	.65	—	.66
Alum, ammonia lump.	lb.	.04	—	.04 $\frac{1}{2}$
Alum, chrome ammonium	lb.	.18	—	.20
Alum, chrome potassium	lb.	.30	—	.35
Alum, chrome, 80%	lb.	.22	—	.23
Alum, potash lump.	lb.	.05 $\frac{1}{2}$	—	.06

Aluminum sulphate, technical.....lb.	.017 $\frac{1}{2}$	.02
Aluminum sulphate, iron free.....lb.	.03 $\frac{1}{2}$	.03 $\frac{1}{2}$
Ammonia aqueous, 26 per cent. carbons.....lb.	.04	.05
Ammonium carbonate.....lb.	.10 $\frac{1}{2}$	.11 $\frac{1}{2}$
Ammonium nitrate.....lb.	.14	.14 $\frac{1}{2}$
Ammonium sulphate domestic.....lb.	.047 $\frac{1}{2}$	.05
Acetic acetate.....gal.	3.50	4.00
Arsenic, white.....lb.	.17	.18
Arsenic, red.....lb.	.30	.60
Barium chloride.....ton	90.00	95.00
Barium sulphate (Blanc Fixe) powder.....lb.	.04	.04 $\frac{1}{2}$
Barium nitrate.....lb.	.11	.11 $\frac{1}{2}$
Barium peroxide basis 70 per cent.....lb.	.27	.29
Bleaching powder 35 per cent chlorine.....lb.	.03 $\frac{1}{2}$	.03 $\frac{3}{4}$
Borax, crystals, sacks.....ton	45.00	.08
Braunstone, crude.....lb.	.01 $\frac{1}{4}$	.01 $\frac{1}{2}$
Bromine, technical.....lb.	1.30	1.35
Calcium, acetate, crude.....lb.	.03	.03 $\frac{1}{2}$
Calcium, carbide.....ton	80.00	90.00
Calcium chloride, 70-75 per cent, fused, lump.....ton	26.00	..
Calcium peroxide.....lb.	1.70	1.75
Calcium phosphate.....lb.	.30	.36
Calcium sulphate.....lb.	.01 $\frac{1}{4}$	.01 $\frac{1}{2}$
Carbon bisulphide.....lb.	.04	.04 $\frac{1}{2}$
Carbon tetrachloride, drums.....lb.	.16 $\frac{1}{4}$	.16 $\frac{3}{4}$
Caustic potash, 82-92 per cent.....lb.	.78	.88
Caustic soda, 75 per cent.....lb.	.15 $\frac{3}{8}$	.14 $\frac{1}{2}$
Chlorine, liquid.....lb.	.15	.16 $\frac{1}{4}$
Copperas.....100 lb.	1.00	1.15
Copper carbonate.....lb.	.33	.35
Copper cyanide.....lb.	.70	.75
Copper sulphate, 99 per cent, large crystals.....lb.	.09	.09 $\frac{1}{2}$
Cream of tartar, crystals.....lb.	.43	.43 $\frac{1}{2}$
Epsom salt, bags.....100 lb.	3.75	4.00
Formaldehyde, 40 per cent.....lb.	.13 $\frac{1}{2}$	.13 $\frac{3}{4}$
Gilber's salt.....lb.	.90	.95
Glycerine, bulk, C. P.....lb.	.54	.55
Iodine, resublimed.....lb.	3.50	3.55
Iron oxide.....lb.	.02	.08
Lead acetate, white crystals.....lb.	.14	.14 $\frac{1}{2}$
Lead arsenate.....lb.	.10	.10 $\frac{1}{2}$
Lead nitrate.....lb.	.16 $\frac{1}{2}$	.17
Litharge, American.....lb.	.08 $\frac{1}{2}$	.10
Lithium carbonate.....lb.	1.00	1.02
Manganese dioxide.....lb.	.60	.65
Magnesium carbonate, tech.....lb.	.24	.26
Nickel, salt, single.....lb.	.14	.14 $\frac{1}{2}$
Nickel, salt, double.....lb.	.11	.11 $\frac{1}{2}$
Phosphorus, red.....lb.	1.10	1.50
Phosphorus, yellow.....lb.	.85	.90
Potassium bichromate.....lb.	.36	.38
Potassium bromide granular.....lb.	1.00	1.01
Potassium carbonate calcined, 80-85 per cent.....lb.	.90	.91
Potassium chlorate, crystals.....lb.	.58	.60
Potassium cyanide, 98-99 per cent.....lb.	1.85	1.90
Potassium iodide.....lb.	2.90	2.92
Potassium muriate 80-85 p. c. basis of 80 p. c. ton.....lb.	40.00	41.00
Potassium nitrate.....lb.	.29	.31
Potassium permanganate.....lb.	3.50	3.75
Potassium prussiate, red.....lb.	2.50	2.75
Potassium persulphate, yellow.....lb.	.90	.91
Potassium sulphate, 90-95 p. c. basis 90 p. c. ton.....lb.	275.00	280.00
Rochelle salts.....lb.	.36	.36 $\frac{1}{2}$
Sal ammoniac, gray gran.....lb.	.11	.12
Sal ammoniac, white gran.....lb.	.18	.18 $\frac{1}{2}$
Sal soda.....100 lb.	1.10	1.15
Salt cake.....100 lb.	.95	1.05
Silver cyanide.....oz.	.70	..
Silver nitrate.....oz.	.47 $\frac{1}{2}$	..
Soda ash, 58 per cent, light, flat.....lb.	.93	.03 $\frac{3}{4}$
Soda ash, 58 per cent, dense, flat.....lb.	.93 $\frac{1}{2}$	.03 $\frac{3}{4}$
Sodium acetate.....lb.	.09	.10
Sodium benzoate.....lb.	6.50	7.00
Sodium bicarbonate, domestic.....lb.	1.90	2.00
Sodium bichromate.....lb.	.16 $\frac{1}{2}$	.17
Sodium bisulphite, powd.....lb.	.04 $\frac{1}{2}$	.05
Sodium chlorate.....lb.	.25	.26
Sodium cyanide.....lb.	1.50	1.10
Sodium fluoride, commercial.....lb.	.11 $\frac{1}{2}$	.12
Sodium hypsulphite.....lb.	.01 $\frac{1}{4}$	.02
Sodium nitrate, refined.....lb.	.05 $\frac{1}{4}$	.05 $\frac{1}{2}$
Sodium nitrite.....lb.	.14	.15
Sodium peroxide.....lb.	1.00	1.10
Sodium phosphate (tri).....lb.	.04 $\frac{1}{2}$	.05
Sodium prussiate, yellow.....lb.	.31	.32
Sodium silicate, liquid, 40 deg.....100 lb.	1.05	1.25
Sodium sulphate, 30 per cent crystal, crude.....lb.	.03	.03 $\frac{1}{4}$
Sodium sulphide, 60 per cent, fused.....lb.	.03 $\frac{1}{2}$	.04
Sodium sulphite.....lb.	.03 $\frac{1}{2}$	.03 $\frac{1}{2}$
Strontium nitrate.....lb.	.25	.28
Sulphur chloride, dark.....lb.	.09 $\frac{1}{2}$	.10
Sulphur dioxide, liquid, in cylinders.....lb.	.11 $\frac{1}{2}$	..
Sulphur, flowers, sublimed.....100 lb.	2.55	2.60
Sulphur, roll.....100 lb.	2.15	2.20
Sulphur, crude.....ton	45.00	..
Tin bichloride, 50 deg.....lb.	13.12 $\frac{1}{2}$	..
Tin oxide.....lb.	.54	.55
Zinc carbonate.....lb.	.24	.26
Zinc chloride.....lb.	.16	.17
Zinc cyanide.....lb.	.50	.50
Zinc dust.....lb.	.11 $\frac{1}{2}$	.12
Zinc oxide, American process, XX.....lb.	.06 $\frac{1}{2}$	.07
Zinc sulphate.....lb.	.06 $\frac{1}{2}$	..

Coal Tar Products (Crude)

Benzol, pure, water white.....gal.	.58	.60
Benzol, 90 per cent.....gal.	.58	.60
Toluol, pure, water white.....gal.	1.80	1.90
Xylo, pure, water white.....gal.	1.90	2.00
Solvent naphtha, water white.....gal.	.20	.22
Solvent naphtha, crude heavy.....gal.	.15	.18
Creosote oil, 25 per cent.....gal.	.30	.32
Dip oil, 20 per cent.....gal.	.30	.30
Pitch, various grades.....ton	8.00	20.00
Carbolic acid, crude, 95-97 per cent.....lb.	.90	.95
Carbolic acid, crude, 50 per cent.....lb.	.50	.60
Carbolic acid, crude, 25 per cent.....lb.	.28	.30

Intermediates, Etc.

Alpha naphthylamine.....lb.	1.10	1.25
Aniline oil.....lb.	.27 $\frac{1}{2}$	.28
Aniline salts.....lb.	.29	.31
Anthracene, 80 per cent.....lb.	7.50	8.00
Benzaldehyde.....lb.	4.00	4.50
Benzidine, base.....lb.	1.85	2.00
Benzidine sulphate.....lb.	1.50	1.60
Benzole acid.....lb.	7.50	8.00
Beta Naphthol, sublimed.....lb.	.80	.85
Dinitrochlor benzol.....lb.	.47	.50
Dimethylamine.....lb.	.56	.60
Diphenylamine.....lb.	.90	1.00
H-Acid.....lb.	Nominal	..
Metaphenylenediamine.....lb.	1.35	1.50
Monochlorobenzol.....lb.	.34	.35
Naphthalene, flake.....lb.	.09 $\frac{1}{2}$	.20 $\frac{3}{4}$
Naphthalene, crude.....lb.	1.75	2.00
Nitro naphthalin.....lb.	.45	.55
Ortho-toluidine.....lb.	1.25	1.30
Para-aminodiphenol base.....lb.	3.75	4.00
Paranitrobenzyl.....lb.	1.30	1.25
Paraphenylenediamine.....lb.	3.50	3.75
Para toluidine.....lb.	2.00	2.10
Phenol, U. S. P.....lb.	.43	.44
Resorcin, technical.....lb.	9.00	..
Resorcin, pure.....lb.	16.50	17.00
Salicylic acid.....lb.	.80	.85
Salol.....lb.	1.40	1.50
Sulphanilic acid.....lb.	.30	.32
Tolidin.....lb.	3.00	..
Toluidine-mixture.....lb.	.75	.80

Petroleum Oils

Crude (at the Wells)

Pennsylvania.....bbl.	3.05	..
Corning, Ohio.....bbl.	2.10	..
Somerset, Ky.....bbl.	2.13	..
Wooster, Ohio.....bbl.	2.05	..
Indiana.....bbl.	1.73	..
Illinois.....bbl.	1.87	..
Oklahoma and Kansas.....bbl.	1.70	..
Caddo, La., light.....bbl.	1.80	..
Corsicana, Tex., light.....bbl.	1.70	..
California.....bbl.	.73	.82

Lubricants

Black, reduced, 29 gravity, 25-30 cold test.....gal.	13 $\frac{1}{2}$	.14
Cylinder, light.....gal.	2.10	.25
Cylinder, dark.....gal.	.18	.19
Extra cold test.....gal.	.26	.31
Paraffine, high viscosity.....gal.	29 $\frac{1}{2}$	.30
Paraffine, 993 sp. gr.....gal.	29 $\frac{1}{2}$	.22
Paraffine, 865 sp. gr.....gal.	18 $\frac{1}{2}$	.19

Flotation Oils

Pine oil, steam distilled.....gal.	.59	..
Pine oil, destructively distilled.....gal.	.47	..
Pine tar oil, light.....gal.	.19	..
Pine tar oil, double refined.....gal.	.30	..
Pine oil, light.....gal.	.37	..
Pine oil, heavy.....gal.	.26	..
Turpentine, crude.....gal.	.18	..
Pine tar, thin.....gal.	.18	..
Hardwood oil, f.o.b. Michigan.....gal.	.16	..
Creosote, coal tar neutral.....gal.	.15	..
Creosote, coal tar, acid.....gal.	.21	..

Vegetable and Other Oils

China wood oil.....lb.	13 $\frac{1}{2}$	.13
Cottonseed oil, crude.....gal.	.89	..
Linseed oil, raw, cars.....lb.	1.00	..
Peanut oil, crude.....gal.	1.00	..
Rosin, 280 lb. cask.....bbl.	6.00	..
Rosin oil, first run.....gal.	.38	..
Rosin, oil, fourth run.....gal.	.67	..
Soya bean oil, Manchuria.....lb.	.13	..
Turpentine, spirits.....gal.	47 $\frac{1}{2}$	..

Miscellaneous Materials

Barytes, floated, white foreign.....ton	38.00	40.00
Barytes, floated, white domestic.....ton	25.00	35.00
Beeswax, white pure.....lb.	.52	..
Caruba wax, highest grade.....lb.	.51	..
Chalk, light, precipitated, English.....lb.	.03	.06
Feldspar.....ton	8.00	12.00
Fuller's earth, powdered.....100 lb.	.80	1.05
Red lead, dry, carloads.....lb.	10 $\frac{1}{2}$	..
Sapstone.....ton	10.00	12.50
Talc, American, white.....ton	10.00	13.00
White lead, dry.....lb.	.09 $\frac{1}{4}$	..

Refractories, Etc.

(F.O.B. Works)

Chrome brick.....net ton	Nominal	..
Chrome cement, Grecian.....net ton	60.00	..
Clay brick, 1st quality fireclay.....per 1000	45.00	..
Clay brick, second quality.....per 1000	30.00	..
Magnesite, Grecian, dead burned.....net ton	..	90.00
Magnesia brick, Grecian, 9x4 $\frac{1}{2}$ x2 $\frac{1}{2}$.....net ton	..	140.00
Silica brick.....per 1000	..	45.00

Ferrolloys

Ferro-carbon-titanium, carloads.....lb.	12 $\frac{1}{2}$	..
Ferrocromium.....lb.	Nominal	..
Ferromanganese, domestic, delivered.....ton	300.00	325.00
Ferromanganese, English.....ton	185.00	..
Ferromolybdenum, per lb. of Mo.....lb.	4.00	..
Ferrosilicon, 50 per cent carloads del. Pitts-burgh.....ton	200.00	250.00
Ferrosilicon, 60 per cent, contract, per 1000.....ton	100.00	..
Ferrotungsten, 75-85 per cent, f.o.b. Pitts-burgh.....lb.	1.95	..
Ferrovanadium f.o.b. works.....lb.	2.75	3.00

INDUSTRIAL

Financial, Construction and Manufacturers' News

Financial

Archipelago Copper Company, Delaware, has been incorporated with a capital of \$2,500,000 to produce copper, gold, zinc, etc. The incorporators are S. L. Howard, L. H. Guntheg, A. W. Britton, all of New York.

The Atlas Steel Casting Company, 1963 Elmwood Avenue, Buffalo, N. Y., has increased its capital from \$150,000 to \$100,000 in expansion.

The Barrett Company, Philadelphia, Pa., successor to the former American Coal Products Company, has filed notice of increase in its capital stock from \$20,000,000 to \$37,000,000 for extensions. The new issue will include \$10,000,000 in common and \$7,500,000 in preferred stocks. William H. Childs is president of the company.

Bernicdale Coal Company, Inc., Binghamton, N. Y., has been incorporated with a capital of \$100,000. Business: coal, fuel and petroleum products. The incorporators are L. M. Bissell, E. E. Powell, 43 Orton Avenue, Binghamton.

Eucham Coal, Timber and Mineral Corporation, Delaware, has been incorporated with a capital of \$1,000,000 to deal in minerals and oils. The incorporators are F. D. Buck, George W. Dillman, M. L. Horty, Wilmington, Del.

The C. B. Textile Engineering Company, 417 Romaine Building, Paterson, N. J., has been incorporated with a capital of \$125,000 to manufacture oxygen, nitrogen and chemicals for textile use. The incorporators are C. P. Buhl, A. Crevier and H. L. Duke, all of Paterson.

California Alkali Company, San Francisco, organized for the purpose of constructing and equipping works for the manufacture of soda ash and other alkali products, has been permitted by Commissioner of Corporations H. L. Carnahan to sell 2000 shares of its preferred stock for \$2,000 cash and to issue 15,000 shares of its common stock in consideration of a transfer to the company of secret processes and of services rendered in investigation, exploration and promotion of the company. It is estimated approximately \$20,000 will be required for the acquisition of a factory site, \$120,000 for building and equipment and \$50,000 for working capital. The plant is to be constructed on Owens Lake, Inyo County.

Carolina Chemical Works, Cleveland, Tenn., has been incorporated with a capital of \$10,000 to deal in potash. The incorporators are A. L. Kirkpatrick, M. J. Shyer, Oscar C. Schwarzenberg and others.

Charleston Chemical Company, Charleston, Tenn., has been incorporated. The incorporators are A. L. Kirkpatrick, Melvin J. Shyer, Oscar C. Schwarzenberg and others, to manufacture potash and by-products.

The Cleveland Brass & Copper Mills of New York has been incorporated with a capital of \$1,050,000 to manufacture brass, copper, other metals, etc. The incorporators are H. A. Gould, E. C. Brunsat, S. H. Moore, J. H. Foeter, Hydraulic Pressed Steel Company of Cleveland, Ohio.

The Columbia Chemical Construction Company, Philadelphia, Pa., has filed articles of incorporation at Dover, Del., with a capital of \$100,000, to manufacture chemicals. Normandy, Craig, Frederick Snyder and Herbert L. Maris, Philadelphia.

Columbia Dye Works, Inc., New York, has been incorporated with a capital of \$50,000 to deal in dyes. The incorporators are B. J. Dowden, W. A. Wilson, H. F. Sawyer, 417 Marlboro Road, Yonkers.

The Crossley Chemical Company, Brooklyn, N. Y., has been incorporated with a capital of \$40,000. The incorporators are H. B. Deyo, E. D. Loughman and C. H. Bailey, Elmhurst.

The Detroit Graphite Company declared a stock dividend of 100 per cent on the common and preferred at the annual meeting of stockholders. This dividend, with a cash dividend of 10 per cent declared a few months ago, marks the close of the most prosperous year in the company's history, the gross business being more than

double that of the previous year. The company is now capitalized at \$600,000, of which \$100,000 is preferred. Additions to the factory on Twelfth Street, now under construction, and others authorized by the directors will greatly increase the output during 1917.

The Eastern Copper Company, Brooklyn, N. Y., has been incorporated with a capital of \$1,500,000. The incorporators are F. H. Lathrup and J. K. Turner.

Eastern Foundry Supply Company, Boston, Mass., has been incorporated with a capital of \$20,000. The incorporators are William T. Nicholson, Providence, R. I.; George T. Taber, Boston, and Lester W. Ingram, Boston.

The Edgewater Foundry Company, Edgewater, N. J., has been incorporated with a capital of \$10,000 to operate a foundry. Joseph Fuchs, Frederick Butzahn and A. W. Brain, Edgewater, are the incorporators.

The Federal Iron Works, 207 South Second Street, Camden, N. J., has been incorporated with a capital of \$10,000 to manufacture iron and steel products. The incorporators are M. A. Testa, J. C. and J. M. Schwartz.

Federal Leather Products, Inc., New York, has been incorporated with a capital of \$1,000 to deal in leather and tanning. The incorporators are J. C. Noakes, W. G. Kirk and R. A. Grumm, 60 East Forty-second Street.

The Fiberoid Corporation, Massachusetts, has been incorporated with a capital of \$3,700,000 to manufacture pyroxyline and its compounds. The incorporator is Edmund J. Levine, 53 Fifth Avenue, New York City.

Fort Wayne Rolling Mill Company, Fort Wayne, Ind., has been incorporated with a capital of \$100,000, increasing to \$300,000.

The Fuel Products Corporation, New York, has been incorporated with a capital of \$100,000 to deal in fuels, products, distillates. The incorporators are L. F. Criado, F. C. M. Carlsen and A. C. Lowenthal, 171 Hancock Street, Brooklyn.

Gasoline Products Company, 12 Bayview Avenue, New Jersey, has been incorporated with a capital of \$350,000 to manufacture by-products of gasoline, kerosene, benzine, oils, greases, etc.

General Gasoline Corporation, New York, has been incorporated with a capital of \$175,000 to deal in liquid fuels. The incorporators are W. G. Brown, E. A. Fischer and F. C. Schussler, 5 West 104th Street.

Glassclear Corporation, Manhattan, has been incorporated with a capital of \$500,000 to manufacture glass, wind shields, auto accessories. The incorporators are L. Frazin, 221 West Ninety-second Street, New York City; J. J. Lazaros, 600 West 15th Street, New York City; and A. S. Klein, 922 Teller Avenue, Bronx.

The suit of a stockholder of Harrison Brothers & Company, Grays Ferry Avenue, Philadelphia, Pa., to restrain the sale of the company to the E. L. du Pont de Nemours Company on the ground that the common stockholders had been accorded preference over the preferred stockholders has been thrown (March 19) and agreement reached to consummate the sale. The paint and varnish business of the company is to be acquired for a consideration of \$7,700,000, with all outstanding obligations of the company assumed by the purchaser.

The sale has been ratified by a vote of 32,513 to 438 shares of company stock.

Construction and Operation

Colorado

DENVER.—The Boulder Tungsten Frothington Company, which owns 164 acres of the company lands, a 50-ton concentrating mill and other apparatus necessary to make concentrates, is planning the erection of a refining plant to make ferro-tungsten. A site has been purchased on the outskirts of the city of Boulder adjoining the Den-

ver, Boulder & Western Railway Company's tracks. Construction on the refinery will commence immediately. Mr. J. G. Clark is president and general manager of the company. Mr. M. Rinn is vice president and N. Williams secretary and treasurer.

DENVER.—A company organized under the name of the Colorado Sulphur Products Company plans a factory here for the mining and manufacture of sulphur products. The incorporators are F. C. Ewing, general sales agent of the Crested Butte Anthracite Mining Company, Ronald F. Bulkeley of the Western Chemical Company, and James Gredlitz, an Eastern mining man.

Connecticut

ANSONIA.—The American Brass Company will erect a new factory and foundry building 320 by 98 ft. It will be of brick and steel and will cost about \$150,000.

WATERBURY.—The Waterbury Rolling Mills Company has awarded a contract for the construction of three buildings of brick and steel.

Delaware

WILMINGTON.—The Wilmington Leather Company is having plans prepared for a new six-story factory.

Georgia

SAVANNAH.—The Southern Fertilizer and Chemical Company will construct a \$50,000 plant for the manufacture of fish oil and scrap. Work will be started immediately on the plant plans for which were announced sometime ago.

Indiana

ANDERSON.—The Lippincott Glass Company has started its plant at Alexandria. The company has been held up on account of shortage of raw material.

MUNCIE.—The Whitley Malleable Castings Company of this city will rebuild its plant, which was destroyed by fire, at a cost of \$300,000.

Kansas

OTTAWA.—A large oil refinery is contemplated here by several oil operators who have producing leases near this site. A. F. Vandersall and W. L. Larkin of Oklahoma City are among those interested.

Louisiana

CEDAR GROVE.—Marine Oil & Refining Company, organized with \$500,000 capital, and plans erecting a 20,000 refinery with daily capacity 1200 barrels of oil.

SHREVEPORT.—The DeSoto Oil Refining Company, recently reorganized in New York State with a capital of \$1,250,000, is considering the erection of a refinery to handle oil from the Louisiana field.

Maryland

FROSTBURG.—A co-operative glass plant will be erected here by a company formed by local parties capitalized at \$100,000. The Board of Trade has been active in fostering the project.

Massachusetts

BOSTON.—The Gibby Foundry Company will reopen the plant formerly operated by the Smith & Anthony Company. Light machine castings will be manufactured.

Michigan

MURKESON.—The Lakey Foundry and Machine Company has secured permission to erect a \$200,000 foundry addition to its local plant. The company manufactures motor castings and machinery.

Missouri

ST. LOUIS.—The Railway Tie Company has acquired four acres in Carondelet as a site for a rolling mill that will employ 200 men.

ST. LOUIS.—The Provident Chemical Company has received building permits for two factory buildings which will cost \$47,500.

Montana

ANACONDA.—A large addition will be built to the Washoe sulphuric acid plant which will require 30,000,000 brick.

BITTE.—The Butte-Detroit mill at the Ophir mine is operating successfully. W. L. Creden is managing director of the company. The old mill has been entirely remodeled and the flotation process installed.

Benefiting by the experiments of the Butte & Superior Company, carried on over a period of two years, Mr. Creden installed the complete and perfectly working plant at the Butte-Detroit in two months. The mill has a present capacity of 200 tons of ore per day, but is receiving only from 70 to 100 tons from the Colorado mine of the Davis-Daly Company. However, more ore will be available soon, and work is now going on to double the capacity of the mill. After the capacity will be raised to 600 tons. At present but one tube mill is employed, but another has just been received and will soon be added to the plant. At present the ore all comes from the Colorado mine, below the 1,000-ft. level, and additional zinc ore is being opened, and arrangements are also being made to take ore from other producers.

The Colorado ore runs 15 per cent zinc, and the concentrates run about 52 per cent and 16 ounces in silver, the average varying slightly from month to month, but for some weeks has been steadily increasing. The recovery is stated to be 94 per cent.

The Ophir was formerly the property of the Butte Central & Boston Company, and when the latter failed many labor claims were unpaid. Foreman I. Davidson and associates, who organized the Butte-Detroit, have paid off every dollar of the labor claims of the Butte Central, and as a result the result of the flotation is now put on a good financial working and profit producing basis.

Nevada

GOLDFIELD.—The Silver Mines Corporation, which operates the Great Western at Hornsilver, is erecting a 100-ton cyanide mill and is expected to start within 90 days. The machinery and equipment for the mill was purchased at Rhyolite and was formerly known as the Sunset cyanide plant. Ore from the Great Western mine at Hornsilver, lying 28 miles south of Goldfield, is ideally adaptable to cyanidation, as was proven from shipments aggregating 40,000 tons made a year ago to the big mill at Millers. The ore carried values varying from \$18 to \$60 a ton, while an average of \$30 a ton resulted from the entire lot.

New Jersey

BUTLER.—The new plant of the Berkow Chemical Works, Main Street, recently destroyed by fire prior to entire operation, will be rebuilt. The company proposes to specialize in the manufacture of dyestuffs.

ELIZABETH.—The F. H. Kalbfleisch Company, Balt. Street, Elizabeth, N. J., manufacturer of chemicals, has acquired four acres adjoining its plant, with frontage on the Elizabeth River and the Centennial Railroad of New Jersey, for the erection of new additions.

JERSEY CITY.—The Goldschmidt Thermit Company, manufacturer of welding apparatus, has purchased fifteen building lots adjoining its plant on Johnston Avenue and Bishop Street for proposed extensions. Plans have been filed for an addition to the plant on Johnston Avenue.

JERSEY CITY.—Joseph Dixon Crucible Company, Monmouth, will erect 3-story addition to present plant on Mercer Street to cost \$250,000.

NEWARK.—The Balbach Smelting & Refining Company will build a one-story addition to its plant, 17 x 23 ft., on Avenue R.

NEWARK.—The Elizabethtown Smelting Company has filed plans for a one-story addition to its plant on Newark Street.

NEWARK.—The Trautz Company will build a one-story addition, 50 x 84 ft., to its metal refining plant at 10-12 Delancey Street.

NEWARK.—An explosion March 16, caused by the failure of a drum of a nitrobenzol machine at the plant of the Chemical Company of America, Westfield Avenue, Springfield, wrecked the building of the company.

NEWARK.—The Butterworth-Judson Company, Newark, N. J., manufacturer of chemicals, has filed plans for the erection of four one-story additions to its plant, each 36 x 60 ft., at Avenue R and the Passaic River. A boiler house, 20 x 32 ft., and other smaller structures will also be erected. The estimated cost is \$24,000.

NEWTON.—The Bethlehem Steel Company is arranging for the installation of a large electric crushing plant at its limestone quarries, McAfee Valley, N. J. The plant will have a rated capacity of about 3500 tons per ten-hour day, and is estimated to cost \$300,000. The property produces a high-grade calcitic blast furnace and open-hearth cinder, and the product will be utilized at the company's South Bethlehem works.

PERTH AMBOY.—The Roessler & Hasselacher Chemical Company has commenced the erection of a large addition to its plant at the corner of Commerce and Front Streets. The structure will be three stories, 50 x 100 x 180 ft., brick and reinforced concrete, and will cost about \$180,000. The Stone & Webster Engineering Corporation, Boston, has the contract for erection.

PERTH AMBOY.—The United Dyes Corporation has been organized with a capital of \$500,000 to take over and operate the plant of the Beckman Chemical & Extract Company, located on the city dock property on Front Street. The new owners plan for additions and extensions in the present plant. John D. McQuade, Newark, and Edward Mayner are interested in the new corporation.

PERTH AMBOY.—The Raritan Copper Company has awarded a contract for the erection of a one-story addition to its plant to cost about \$15,000. The Berlin Construction Company, 220 Broadway, New York City, contractors.

New York

COHOES.—The General Electrical Company of Schenectady has purchased the southern part of Cohoes and will erect a big fibre mill to be operated in connection with the Schenectady shops. Fibre will be made from waste paper and will be used for insulating purposes.

NIAGARA FALLS.—The Niagara Falls Gas & Electric Light Company will build a new generating plant to cost \$175,000.

NIAGARA FALLS.—The American Magnesium Corporation, recently incorporated with a capital stock of 500 shares of \$200 par value and 10,000 shares no par value, to carry on business with \$600,000, has established a plant at Niagara Falls, N. Y., and is now producing magnesium ingots. J. H. Seward is president, E. H. Whaley and George O. Seward are vice presidents and D. Burgess is secretary and treasurer.

NIAGARA FALLS.—The Titanium Alloy Mfg. Company, Sugar and Lafayette Streets, Niagara Falls, N. Y., has let contract to the Peckham Construction Company, Mutual Life Building, Niagara Falls, for the erection of additional two-story buildings estimated to cost \$75,000.

ROCKY HILL.—The Bethlehem Steel Company contemplates building a plant here to manufacture forgings for the Watervliet arsenal.

Ohio

AKRON.—The Akron Foundry Company, 526 Washington Street, will build a large addition to its plant, to cost \$18,000.

CINCINNATI.—The John Douglass Company will build an addition to its present plant to cost \$50,000. The new building will be used for the manufacture of clay goods.

CLEVELAND.—The Cleveland Brass and Copper Mills Company has let the contract to Westinghouse Church Kerr Company, N. Y., for the erection of foundry buildings. Five buildings will be erected at a total cost of \$150,000. Henry C. Osborne of the American Multiphase Company is president of the new concern. B. F. Brewster, formerly general manager of the Michigan Copper & Brass Company, is vice president and general manager.

CLEVELAND.—The Monarch Brass Company, 4613 Payne Avenue, N. E., contemplates the erection of a modern foundry adjoining the site of its present structure.

CLEVELAND.—The Cleveland Brass and Copper Mills Company, a new concern composed of Cleveland men headed by Henry C. Osborne, president of the American Multiphase Company, has let contracts for the erection of five buildings to cost \$150,000. It will be the only brass-rolling mill in Ohio.

LORAIN.—The American Sheet and Tinplate Company is seeking additional land for the erection of a large factory to be built in the steel plant district here. Construction work on the sheet and tinplate plant, which will employ 4500 men, is to be started within the next few weeks and it will take three years to complete the plant.

MIDDLETOWN.—The plant of the Miami Iron and Steel Company, which has held several years, is being repaired and will be put into operation within the next few months.

SHARON.—Turner-Fricke Gas Engine Company will erect a modern foundry on North Water Street to manufacture materials for the blast furnace department. All kinds of castings which enter into the manufacture of gas engines will be manufactured.

STEOBENVILLE.—The large paper factory originally built by Hartie Bros. has been actual manufacturing operations. The plant is one of the largest in this part of the country.

TIFFIN.—Many improvements are being made to the plant of the United States Glass Company, and when finished the capacity of the plant will be increased to such an extent that sixty or seventy-five men will be needed.

URBANIA.—Inability to obtain the necessary coal has postponed the opening of the new glass factory in the buildings formerly owned by the Eagle Glass factory.

YOUNGSTOWN.—Brier Hill Steel Company, which recently purchased the Western Reserve Steel Company and a large site adjoining it, expects eventually to make large improvement conditions to its Western Reserve Works.

Pennsylvania

ALLENTOWN.—The Victor Leather Company will erect a large plant for the tanning of leather, all kinds known as chrome kid leather. Mr. Haddock is president of the company and Samuel J. Kistler is secretary and treasurer. It is claimed that Mr. Haddock has a process whereby he can make any color desired. The goat skins to be used will come from Chican, Cuba and the Latin-America States.

BLACKLICK.—Marshall Foundry Company, here, plans the erection addition to present plant to cost \$100,000.

CHESTER.—Scott Paper Company, Seventh and Glenwood Avenues, Philadelphia, plans erecting new branch plant here to cost \$500,000. E. I. Scott, president.

CONNELLSVILLE.—The Sligo Iron and Steel Company has been leased to a group of Pittsburgh capitalists who will begin operation shortly turning out bar iron. Eventually it is planned to erect an open-hearth furnace. J. H. Connell will be general manager of the plant, which has been closed for several years.

HAZARD.—The Alliance Hollow Cement Block Company has commenced the installation of a new crushing plant at its local quarries. The plant will have a capacity of 500 tons of sand daily.

MANHEIM.—Reported United States Asbestos Company plans erecting extensions to double capacity of plant, which now employs about 400 hands. S. R. Zimmerman and Chester L. Hill, Lancaster, owners.

NORRISTOWN.—E. J. Lavino & Company, operating quarry properties at Howellsville, recently purchased, and at Clougher, Pymouth Township, has acquired the quarries of the Green Lane Trap Rock Company, Green Lake, Perkiomen Valley. It is planned to enlarge and increase the capacity of the company.

OIL CITY.—A large modern oil refinery will be erected near the mouth of Two Mile Run, a tributary of the Allegheny River. High grade lubricating oils and greases will be manufactured from Franklin heavy crude. H. H. Gault is president of the company. W. A. Edsall is vice-president, and G. W. Black sales manager of the Peco Oil Company of Franklin, Pa., which will have charge of the sales of the many products.

PHILADELPHIA.—The Water Bureau (Carleton E. Davis, chief) has requested an appropriation of \$10,000 from the Common Council for the purchase of chlorine for the water department.

PHILADELPHIA.—The General Processing Company, Willard and Trenton Avenues, has filed plans for the rebuilding and improvement of its dyeworks and chemical plant, recently purchased from S. R. Zimmerman, with a loss of about \$35,000. William C. Foulds is president of the company.

PHILADELPHIA.—The Barrett Chemical Company has awarded a contract for the erection of a new building, 48 x 80 ft., to its plant at Thirty-sixth Street and Gray's Ferry Road, to cost \$7,500.

PHILADELPHIA.—Joseph Koppelman & Sons, Florist Street, manufacturers of brass and bronze goods, will build a three-story addition to their plant, about 24 x 32 ft.

PHILADELPHIA.—The Midvale Steel Company has purchased from the Manor Real Estate Company a tract of about seven acres of property on the southwest corner of Wissinoming and Locust Streets, for proposed extensions to its plant. Plans have been filed for a new machine shop, 65 x 103 ft., to cost about \$25,000.

PHILADELPHIA.—Caskey & Keen, Inc., remodeling and building department, \$100,000, has purchased a four-story foundry building at the corner of Sixth and Berks Streets, including property about 135 x 171

ft., for a plant for the manufacture of castings and machinery. William J. Steen is head of the company.

POTSTOWN.—The Eastern Steel Company is making preparations for the operation of its Warwick mines, Boyertown, for the production of iron ore for the Potstown furnaces.

POTSTOWN.—The Nagle Steel Company is making extensive improvements and betterments to the plant of the Potts Brothers Iron Company, recently acquired. The work will include the installation of new rolling mill machinery, with transfer table and other equipment.

READING.—The American Boron Products Company, recently organized, is planning for the establishment of a local plant for the manufacture of chemicals. H. O. Miller is president of the company.

SOUTH BETHLEHEM.—The Bethlehem Steel Company has decided to build an eighteen inch and twelve inch mill equipped with traveling tilting tables to roll medium- and structural shapes, such as angles, beams, channels, etc. After considerable investigation it was decided to install a three-high, eighteen-inch, three-stand mill, equipped with traveling tilting tables, to roll medium- and structural shapes, such as angles, beams, channels, etc., in order to fill in and lap the smaller sizes of sections rolled on the twenty-eight-inch structural mill. To further round out this situation it was decided to install sixteen-inch and twelve-inch mills to roll the lighter sections of angles, beams, channels, round flats, and wide flange beams. The mill, which consists of six sixteen-inch stands roughing and four twelve-inch stands finishing. The eighteen-inch mill is run by two recuperative furnaces, gravity discharge, using coke oven gas as fuel. This mill is operated by 1500 horsepower, three-phase, twenty-five cycle, 6,600-volt motor, speed ratio, 133 to 1, to eighty-one r.p.m. The sixteen-inch horsepower, 220-volt compound wound direct current motor, speed range of 133 to eighty-one and one-half r.p.m., making a direct current and reversing current driving unit, capable of speed range as indicated. The two mills are housed in a building 155 ft. in width by 600 ft. in length supported by a crane runway, eighty-five feet span by 250 ft. long, for the handling of billets for heating furnaces. The sixteen-inch and twelve-inch mill, which is housed in the same building, is equipped with run-in cooling beds, with center run-out, backed up with duplicate roller straighteners, shears, gauges, weighing and bundling equipment. This mill is served by two 13 x 34-ft. continuous furnaces of the Morgan type, using coke oven gas as fuel. The power for driving this mill is furnished by 2000-horsepower, 600-volt, 25-cycle, reversing current motor with a speed range of 10 to 100 r.p.m.

Rhode Island

PROVIDENCE.—J. C. Culbert will build a factory for refining metal on Mill Street which will be three stories in height, 50 x 100 ft.

Tennessee

CHATTANOOGA.—It is reported that the Franklin H. Kalbfleisch Company will probably build a factory for the manufacture of sulphuric acid in connection with their large chemical plant at North Chattanooga, Tenn.

KNOXVILLE.—The Ocoee Copper Company, recently organized with \$1,230,000 capital, will develop several hundred acres of copper ore lands in Polk County. The company was formed by a number of Chattanooga business men. The company will proceed at once to install all the necessary machinery.

Texas

HOUSTON.—The Empire Gas and Fuel Company will erect a large refinery on the 800-acre tract on the Houston ship channel here. A pipe line will bring the oil from the Oklahoma and Kansas fields.

Utah

SALT LAKE CITY.—The Utah Iron and Steel Company plans to spend about \$300,000 in extensions to its plant. The company has taken over the location and equipment of the Utah Consolidated Steel Company.

Vermont

MIDDLEBURY.—The Standard Paper Company will begin work on a new building in the spring in the south part of Belvidere Falls, where its present plant is located.

Washington

PT. ANGELES.—Two pulp and paper plants will be shortly built in Port Angeles.

The first will be under charge of Whalen Bros. of Canada, who already operate several plants in British Columbia. It will be financed largely by Peabody-Houghteling & Co. of Chicago. Corporate name is Washington Pulp & Paper Co. It is planned to expend \$1,750,000 in plant. The site has been secured for \$30,000. The capacity will be 120 tons of pulp per day, and the company will also have a newsprint mill and tissue-wrapper paper factory.

The second plant is being put up by Northern Board & Paper Co., of which Chas. H. Myers is manager, 815 White Bldg., Seattle—\$500,000 will be spent. The plant will have a capacity of 80 tons of pulp per day.

The Whalen Bros. plant will utilize Sitka spruce and western hemlock and will use the dry sulphide process with several patented features, including giant chippers which take logs from loom, remove bark, etc., and chip lock direct, instead of usual process of seasoning short lengths for six months, then chipping. The plan is so situated that the use of hemlock for paper pulp is claimed to be only possible by means of their patented process.

PORT ANGELES.—An experimental plant is being constructed in Port Townsend, Wash., for a series of tests in obtaining by-products from kelp. Mr. Frank Missadat, a German chemist, will have charge of the plant. Kelp beds near Port Townsend will supply material.

SEATTLE.—West Coast Chemical Company, manufacturers of dyestuffs, especially sulphur black, has been expanding rapidly during the past year. The company has taken up a large manufacturing of pharmaceuticals.

VANCOUVER.—The Standard Electric Power and Chemical Company, Vancouver, Wash., has been incorporated by C. D. Charles and John T. Jeffrey, of Portland, Ore., and D. P. Smith, Vancouver, to erect a plant to manufacture nitrates and other chemicals from the air. The company is capitalized at \$4,000,000 and owns water-powers on the Deschutes River, which will be developed.

TACOMA.—Atlas Foundry Company plans erecting additional buildings to house their industry; cost \$60,000.

West Virginia

WHEELING.—It is estimated that the steel and iron mills and furnaces which are being erected by the Whitaker-Glessner Company will cost about \$20,000,000. The company has already spent three-fourths of a million dollars for the land and coal deposits in the Beech Bottom Valley. The company has purchased the whole valley covering a distance of a mile and a half in each direction from the town.

WHEELING.—The Hazel-Atlas Glass Company, principal offices in this city, will double the size of its glass plant at Fetterman, near Grafton. The improvements will include new warehouse, extension to the blast house, enlargement of the power house, installation of four additional gas engines, and a complete pumping station.

WHEELING.—Steel mills and glass factories in this district have resumed operation after a delay due to a shortage of gas.

WHEELING.—Whitaker-Glessner Company, here, will erect steel plant and furnaces in Beach Bottom, Brooks Co., W. Va., to cost about \$20,000,000.

Wyoming

CASPER.—The Midwest Oil Company plans to use the casing head gas now being burned at the Snake Creek oil refinery will be erected in this field to recover gasoline from this gas. The refinery will cost between \$50,000 and \$100,000.

Canada

AMHERSTBURG.—Plans being prepared for erecting and work will begin April 1 on a plant for the manufacture of (Gordon S. Rutherford, mgr.) to cost \$300,000, for manufacture of alkali products.

HAILEYBURY.—Ont.—Riordan Pulp & Paper Company, 1 Beaver Hall Square, is erecting sulphate plant here to cost \$100,000.

HAMILTON.—Ont.—Plans being prepared by Prack & Perrine, Hamilton, for erecting and equipping new furnaces, foundry and plant of Carbon & Alloy Steels Co. to cost \$300,000. H. J. Waddell, Canadian Drawn Steel Co., mgr.

OCEAN FALLS. B. C.—The large new paper plant of the Pacific Mills Company, Ltd., is ready for operation and will start April 15. The company is owned and controlled by the Crown-Willamette Paper Company of Portland, Ore., and is backed

by Portland and San Francisco capital. A second and larger unit will be erected shortly directly across the Link River from the new building. The second unit will have a capacity of 125 tons of paper a day, giving the complete plant a capacity of 225 tons daily. When completed the plant will be one of the largest in the world. Most of the paper made will be news print and Kraft paper made by the sulphate and sulphite process.

SMOOTH ROCK FALLS, ONT.—The Mattagami Pulp and Paper Company, Ltd., a \$6,000,000 corporation which was bought in Colorado Springs, Col., is at present constructing a mill at this place which will cost about \$2,000,000. It is on the Mattagami River, connected by three miles of spur railway with the National Transcontinental Railway at Smooth Rock Junction. The plant is of modern concrete construction and will be capable of manufacturing 45,000 tons of sulphate pulp annually. Supplementing the factory is a saw mill at the falls with a capacity of 4,000,000 feet, board measure a year. The plan is so situated that the National Transcontinental Railway furnishes direct outlets to the Atlantic and Pacific seaboard and intermediate markets east and west. Connecting railways include the Temiskaming & Northern Ontario Railway by way of Cochrane to North Bay, and there connecting with the Canadian Pacific and the Grand Trunk ways. On the west the company has outlets over the Algoma Central Railroad by way of Hearst, by way of Michipicoten harbor and Sault Ste. Marie.

The Mattagami company has practically finished development of a water power with a maximum development of 9,000 horsepower, minimum 1000 horsepower, at the mill site at Smooth Rock Falls. About 1000 horsepower will be ample for the company's needs for some time to come, it has additional power at Yellow Falls, eight miles above the mill, of capacity of developing 1000 horsepower minimum, which will be available for use as the company's business expands. S. R. Armstrong, a pulpwood manufacturer of Pennsylvania, is the agent for the company. J. F. Shreve, of this city; W. D. Ross, a Toronto banker and steel maker; N. Bruce McKelvie, of Hayden Stone & Co. of New York and J. M. Robertson of Toronto are directors.

TORONTO, ONT.—Queen City Foundry Co. will rebuild plant partially destroyed by fire with loss of \$100,000.

Manufacturers' Notes

THE INTERSTATE CLAY PRODUCTS COMPANY of Cleveland, Ohio, has opened a Pacific Coast office at 410-412 First St., Seattle. The company handles Denison interlocking tile. The office will be in charge of Albert Armstrong and H. R. Kreitzer. The former has been the company's secretary-treasurer of the Far West Clay Company, of Tacoma, and the latter has been sales manager of the same company.

LIST OF POTASH PRODUCERS OFFERED.—Producers of potash (stone-ash or crude potash, black salts or black flux, and pearlsh or white flux) obtained by the old-time method of leaching wood ashes have been writing to the United States Geological Survey and complaining of the lack of a market for their products. In view of the scarcity of potash in the United States and the need of potassium carbonate for glass and caustic for soap making, and in laundry use especially, the Survey is seeking to remedy this situation. Thirty-three producers have reported to the Geological Survey over 600,000 tons of these materials, valued at 7 to 70 cents a pound according to degree of refinement. This class of materials includes caustic potash, pearlsh, black salts, potassium carbonate, and potassium sulphate with organic and various kinds of inorganic matter. The Survey offers to act as intermediary in producing products and buying of these materials together. A list of such potash and pearlsh producers, particularly mentioning those who report a stock of materials on hand, will be sent by the Survey to any who apply for it.

RUSSIA REQUISITIONS PLATINUM.—According to the February, 1917, issue of *Russia*, the requisitioning of Russian stocks of platinum by the Imperial Government is foreshadowed by an order forbidding sales of the metal, and requiring that stocks in hand be held pending further action by the authorities. The Imperial Government district in 1916 (the bulk of the world supply coming from this region) fell to between 100 and 120 pounds—about one-third of the normal supply. The Government is returning from hand-washing, and lack of spare parts for dredges interfered with the output of mechanical plants.

SARCO COMPANY, INC., maker of steam traps and temperature regulators, of Woolworth Building, New York, have added Buffalo to their list of branch offices. The new office is located at 1225 Ellicott Square and is under the charge of P. D. Harger, M.E.

NEW RENNERTFELT FURNACE INSTALLATION.—Hamilton & Hansell have recently sold to the Oklahoma Iron Works, Tulsa, Okla., through their agent, T. H. Gustafson, a one-ton Rennerfelt furnace, rated at 300 kw., for their new steel foundry. In addition to this, two other Rennerfelt furnaces have been sold which are going to Europe. The new and larger Rennerfelt furnace at the Parsons Company, Newton, Iowa, is now in operation. The Chicago Bearing Metal Company, Chicago, Ill., has installed two 1-ton Rennerfelt electric arc furnaces rated at 300 kw. each, for melting copper alloys.

NEW BRANCH OFFICES FOR TRAYLOR ENGINEERING.—Branch offices have been opened by John A. Traylor, western manager of the Traylor Engineering & Construction Company and the Cement Gun Co., with headquarters at Salt Lake City, Utah. These offices will be located at Spokane, Wash., for the Northwest district, in charge of C. H. Abell, chemical engineer, and at El Paso, Tex., for the Southwest district, in charge of Robert M. Leahody, sales engineer.

FERROZIRCONIUM AND ZIRCONIUM OXIDE.—The Foots & Co. Company's monthly publication "Mineral Foots Notes" for March contains some interesting information on ferrozirconium and pure zirconium oxide by H. C. Meyer. This alloy is finding a limited application in the steel industry as a scavenger for removing nitrogen and oxides from steel. One of the most recent alloys of zirconium produced on the market contains essentially 70 per cent iron, 30 per cent zirconium, with the residue mainly iron or an iron group metal. Small percentages of titanium and aluminum are also introduced in these alloys, which are covered by U. S. Patent No. 1,151,160, it is claimed are not subject to oxidation and are highly resistant to chemical reagents. They have a metallic luster and take a silvery steel-like polish. They are readily malleable and it is suggested that they may find important application in the manufacture of drawn filaments for incandescent lamps. Such filaments are claimed to have the property of selective radiation; in other words, emit more light than corresponds to the temperature at which they are heated by the electric current. This implies a considerably lower wattage per candle power than is now required by the average metal filament lamp. A typical analysis of some of these alloys produced under the above patent show: zirconium 65 per cent, iron 26 per cent, titanium 0.12 per cent, and aluminum 7.7 per cent. The production of the alloy is accomplished by reduction with finely divided aluminum together with the mixed oxides of iron, titanium, etc., or whatever metals it is desired to introduce. The alloy can be produced by heating the mixed oxides in a graphite crucible in an electric furnace, using either zircon or zirkite as a source of zirconium. An English patent, No. 29,376, covers the use of ferrozirconium as a scavenger. The alloy contains 20 per cent of the element and is used in the amount equal to about 1 per cent of the metal in steel. Zirconium oxide or zirconia is a pure white substance having a specific gravity of 5.6 and a melting point ranging from 2700 to 3000 deg. C. At a melting point of this importance, commercial applications of zirconium oxide: (1) as a refractory body; (2) as an opacifier or clouding agent in enamels. Various other uses of the element both in this country and abroad, covering the manufacture of refractory vessels from zirconia, for which is claimed remarkable heat-resisting properties. In one instance the element is mixed with 3 per cent to 10 per cent of magnesia, using starch, phosphoric acid, gelatinous zirconium hydroxide or borates as binders. The mixture is pressed into a furnace at a temperature ranging from 2000 to 2300 deg. C., thus producing a body which is practically impervious to all liquids and unaffected by strong acids or alkali fumes. Owing to the extremely low coefficient of expansion, such ware can be subjected to very sudden changes of temperature, in this way resembling porcelain but unlike the latter, is not subject to devitrification. Prior to 1915 no extensive research work had been done in America on the production of pure zirconium or compounds thereof, but the inability to secure the product from abroad has spurred American investigators to develop commercial processes, so that there is now being produced in this country, running 98 per cent to 99 per cent ZrO₂ in time being placed on the market at a price

in the neighborhood of 60 cents per pound in ton lots. In the preparation of the pure metal it is extremely important that it be oxide free. Iron, titanium and silica-free iron is particularly objectionable, as it acts as a flux. A very high-grade commercially pure zirconium oxide gives the following analysis: ZrO₂ 99.91 per cent; TiO₂ 0.04 per cent; Fe₂O₃ 0.01 per cent; Al₂O₃ 0.01 per cent; SiO₂ 0.02 per cent; total 99.99 per cent. A recent European patent covers the use of zirconium oxide as a surfacing material for aluminum, or other refractory bricks and products. It is claimed by this process that a thin layer of zirconium oxide on a suitable lining renders the coating with a suitable resistance to slag corrosion.

RUSSIA'S FOREIGN TRADE.—Russia for February, 1917, gives the following data on Russian foreign trade: For nine months of 1916 the total value of Russia's foreign trade was Rs. 2,452,830,000 (\$1,057,077,700). For the same period of 1915 the total foreign trade was Rs. 387,680,000 (\$505,655,200); for 1913 it was Rs. 2,078,189,000 (\$2,167,675,750). Total imports: First nine months, 1916, Rs. 1,631,403,000 (\$840,172,545); 1915, Rs. 716,517,000 (\$369,021,705); 1913, Rs. 1,000,000,000 (\$517,899,595). Total exports: First nine months, 1916, Rs. 421,177,000 (\$216,906,155); 1915, Rs. 271,133,000 (\$139,633,495); 1913, Rs. 1,072,570,000 (\$552,373,550).

The Principal Imports at Vladivostok from the United States and Japan in the figures below: From the United States: Agricultural machinery, Rs. 2,806,000 (\$1,445,090); machinery, not electric, Rs. 1,771,000 (\$2,152,065); cultural machinery, Rs. 1,771,000 (\$2,152,065); motor cars and trucks, Rs. 33,545,000 (\$17,275,675); cotton, Rs. 30,633,000 (\$75,995,575); steel, Rs. 25,241,000 (\$3,925,115); iron and steel manufactures, Rs. 25,115,000 (\$230,350); cloth, other woollen goods, Rs. 18,208,000 (\$9,377,120); copper, Rs. 18,812,000 (\$9,688,180); boots and shoes, \$8,820,000 (\$3,082,820); rope and twine, Rs. 1,146,000 (\$1,066,190); iron and steel goods, Rs. 19,253,000 (\$9,915,295); boots and shoes, Rs. 9,481,000 (\$4,892,715); cloth, other woollens, Rs. 6,588,000 (\$3,271,575); antimony, Rs. 4,338,000 (\$2,234,670); copper, manufactures of, Rs. 4,236,000 (\$2,181,540); zinc, Rs. 3,963,000 (\$2,045,045); sulphur, Rs. 3,725,000 (\$1,937,575); tanning extracts, Rs. 2,004,000 (\$1,032,060).

POTASH FROM CALIFORNIA.—The American Trona Corporation is now producing a large quantity of potash from its refinery at San Pedro, Cal., after several years of development and research work. The company is offering potassium chloride 60 to 99 per cent and natural trona containing 12 to 99 per cent sodium bicarbonate, 52 per cent sodium metaborate, 14 per cent sodium chloride, balance water of crystallization. The company has a New York office at 233 Broadway, and Los Angeles, Cal., office at 366 Pacific Building.

Another important addition to the potash supply of the United States comes with the development of a new field of production at Searles Marsh, section 18, extreme northwestern corner of Bernardino County, Cal., not far from the famous Death Valley country. A large modern potash plant has just been completed by the Pacific Coast Borax and the Solvay Process companies, and operations will be begun about the first of April. It is estimated that the output will be about 1600 tons per month of muriate of potash, 35 per cent better grade potash. A new process for the refinement of the raw product has been solved by the two companies and is reported to be very successful. The new field is about 1500 acres of desert, owned and owned by the interested concerns, so that there are no obstacles to the conduct of operations once the machinery is started. Refined facilities have been extended to the field.

BACHARACH INSTRUMENT COMPANY TAKES LARGER QUARTERS.—The Bacharach Industrial Instrument Company, Pittsburgh, Pa., formerly at 14 Wood Street, has moved into larger quarters at 207 West Avenue. These new headquarters has been made necessary by the increased demand for the company's gas meters, pressure and draft recorders, CO₂ indicators, thermometers, etc. **THE VANADIUM-ALLOYS STEEL COMPANY.**—Pittsburgh and Latrobe, Pa., announce that arrangements have been completed whereby the following firms will represent them in the sale of their high speed steel, alloy and carbon tool steels. The latter, generally called for sizes will be carried at the various warehouses. These stocks are in addition to the stock carried by the Vanadium-Alloys Steel Company at their mill at Latrobe and their Pittsburgh warehouse. E. T. Ward's Sons, 44 Farnsworth St., Bos-

ton, Mass.; Geo. Nash Company, 304 Hudson Street, New York, N. Y.; Field & Company, Inc., 721 Arch Street, Philadelphia, Pa.; Geo. Nash Company, 646 Washington Boulevard, Chicago, Ill.

Manufacturers' Catalogs

J. P. DEVINE COMPANY, Buffalo, N. Y., have issued an attractive little booklet dealing with Devine apparatus for the chemical and allied industries, describing autoclaves, reduction kettles, nitrating kettles, fusion kettles, chemical kettles, tilting kettles, vacuum pans, vacuum evaporators, jacketed pans, digestors, steam jacketed valves and steam jacketed pipes.

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, East Pittsburgh, Pa., have issued Catalog 5-A, January, 1917, describing Westinghouse insulating materials and supplies; Catalog 3-A, describing Westinghouse watt-hour meters; Catalog 3-B, describing Westinghouse instruments, switchboard, portable and traction instruments, ammeter shunt, transformers and relays, and Special Publication 1572-2-17 describing protective relays, dealing with their use on alternating current systems.

LINK-BELT COMPANY, Chicago, Ill., have issued Bulletin No. 282, dealing with the installation of Link-Belt Silent chain in chemical works.

H. REEVE ANGEL & CO., Inc., New York, has issued a booklet dealing with different Wharton papers which it is exclusive agent for in this country.

HESS & SON, Philadelphia, have issued a booklet on "Epicassit" for tin, lead and zinc coatings, describing the different brands for the different metals.

THE PANTRY SPRAY ENGINEERING COMPANY, 93 Federal Street, Boston, Mass., has issued a new bulletin, No. 501, on "Spraco" products. The bulletin gives a condensed description of the different spraco developments in spray cooling equipment, air washing and cooling equipment, paint spraying equipment, park sprinklers, flow meters and nozzles for general use.

Other New Publications

PRODUCTION OF COPPER, GOLD, LEAD, NICKEL, SILVER, ZINC AND OTHER METALS IN CANADA DURING THE CALENDAR YEAR 1915. By John McLeish. Published by the Canada Department of Mines, Mines Branch, Ottawa, Canada.

PRODUCTION OF CEMENT, TIME CEMENT, PORTLAND CEMENT AND OTHER STRUCTURAL MATERIALS IN CANADA DURING THE CALENDAR YEAR 1915. By John McLeish. Published by the Canada Department of Mines, Mines Branch, Ottawa, Canada.

PRODUCTION OF COAL AND COKE IN CANADA DURING THE CALENDAR YEAR 1915. By John McLeish. Published by the Canada Department of Mines, Mines Branch, Ottawa, Canada.

MINERAL PRODUCTION OF CANADA DURING THE CALENDAR YEAR 1916. Prepared by John McLeish. This is a preliminary report issued by the Canada Department of Mines, Mines Branch, Ottawa, Canada.

ANTIMONY, ARSENIC, BISMUTH, SELENIUM AND TELLURIUM IN 1915. By Frank L. Hess. Issued March 13, 1917. U. S. Geological Survey Report.

A SPECIFIC GRAVITY BALANCE FOR GRAVIMETRY. By David Edwards. A publication of the Bureau of Standards (Technologic Paper No. 89), issued Feb. 23, 1917, by the Department of Commerce.

ANALYSES OF COAL PURCHASED BY THE GOVERNMENT 1908-1915. By Geo. S. Pope. Bureau of Mines Bulletin 119.

YEAR BOOK FOR 1915, ILLINOIS STATE GEOLOGICAL SURVEY. Contains Administrative Report and Economic and Geological Papers. Published by the Illinois State Geological Survey, Frank W. De Wolf, director.

SOME FACTS AND FIGURES ABOUT NORTH CAROLINA AND HER NATURAL RESOURCES. Prepared by North Carolina Geological and Economic Survey and issued at Raleigh, N. C., by the Survey.

OIL INVESTIGATIONS IN ILLINOIS IN 1916. Bulletin No. 35 of Illinois Geological Survey, Urbana, Ill. **PROPOSED CLINTON COMMERCIAL CLUB, CLINTON, IOWA, FOR THE LOCATION OF THE GOVERNMENT ARMOR PLANT THERE.** Issued by the Commercial Club, Clinton, Iowa.

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Contents for April 15, 1917

EDITORIAL:

The War	413
Steel in War	414
A Suggestion on Fire Brick	414
Switzerland and the Chemical Industry	415
The Late David H. Browne	415

READERS' VIEWS AND COMMENTS:

Methyl Alcohol and Acetone as By Products of the Soda Pulp Industry. By Jas. C. Lawrence	416
Bail Mills. By H. W. Hardinger	417
Vanadium Check in High-Speed Steel Analysis. By Ed- ward C. Kraus	418
Coming Meetings and Events	418
Big American Dyestuff Companies Merge	418
The Western Metallurgical Field	418
The Training and the Work of the Chemical Engineer. (Sym- posium before the Faraday Society)	420
Preparedness Census of Technical Men	422
The Late David H. Browne	423
Annual Meeting of the American Chemical Society at Kansas City	423
Exfoliation and Carbon Concentration in the Case Hardening of Steel. By Edwin P. Stenger	424
Electrical Porcelain. By L. E. Barringer	433
Beet Molasses: Its Composition and Utilization. By Sidney J. Osborn	436
Another Tin Smelter for the United States	443
Some Studies on the Methods of Recovering Antimony from its Ores. By Volatilization Processes. By J. A. DeCew	444
Grading of Crushed Stone and Gravel, Feldspar, Fireworks and flour. By Edward S. Wlard	449
RECENT CHEMICAL AND METALLURGICAL PATENTS	452
SYNOPSIS OF RECENT CHEMICAL AND METALLURGICAL LITERA- TURE	453
Hydroelectric Exhibit of Canadian Pacific Railway	455
New Electrocyamide Process	456
BOOK REVIEWS	457
PERSONAL	457
Current Market Reports—Iron and Steel Market, Non-Ferrous Metal Market, Chemical Market and Price List	457
Industrial—Financial, Construction and Operation and Manu- facturers' Notes	461

The War

The United States is at war with Germany. The ultimate object is a world peace founded on liberty and justice and the war is the price of such a future peace. Now that the United States is engaged in the mighty conflict, a united American nation stands solidly behind the President, and there is one pledge in every one's heart: "My Country."

From the President's address to Congress we quote: "We are at the beginning of an age in which it will be insisted that the same standards of conduct and of responsibility for wrong done shall be observed among nations and their governments that are observed among the individual citizens of civilized states. We have no quarrel with the German people. We have no feeling toward them but one of sympathy and friendship. It was not upon their impulse that their Government acted in entering this war. It was not with their previous knowledge or approval. It was a war determined upon as wars used to be determined on in the old unhappy days when people were nowhere consulted by their rulers and wars were provoked and waged in the interest of dynasties or of little groups of ambitious men who were accustomed to use their fellow men as pawns and tools."

* * *

The President's safe and sane advice to this country to keep a level head on our shoulders is as true and important today as when it was made at the start of the war in 1914. It is particularly fitting for American engineers and chemists. Suddenly they have become in a large measure the trustees of the country's safety. Having been the upbuilders of the country they now become its defenders. Much has already been done during the past year under the leadership of the Naval Consulting Board and the Council of National Defense. Very valuable work has been done by the different engineering and chemical societies in the preparation and compilation of data showing the industrial strength of the various industries and providing exact knowledge of what any manufacturer can do. But very much more remains to be done, very much more earnest thinking and very much more solid action.

But thinking must precede action, otherwise there will be chaos. As an example, we have already urged that chemists who can do productive work in making munitions should be restrained from enlisting to serve with the colors. It is patriotism turned upside down for a young man who is familiar, for instance, with nitration processes, to march behind the band. The place where he can serve his country most efficiently is right in the works and in the laboratory. We do not mean that every drug clerk should be freed from the

obligation to go to the front, but research and works chemists and chemical engineers are needed more keenly now than ever before in their profession, for their country's sake.

Likewise, the *Engineering and Mining Journal* is right in recommending mining men not to be too quick in volunteering for the army, but to wait for the special call for recruits for mining and tunneling companies. We should profit from the experience in Great Britain. When it was found there that sappers and miners were needed, it was also found that many of the experienced men were already at the front with the infantry and cavalry, and it was hard to get them out, but it had to be done.

These are just two examples showing that it is not enough to call out the fighting force of the country, but that it is just as important to see to it that each man is placed at the right place—not where he would like to be, but where the country needs him most. What is needed, in one word, is organization, not only of the men but of the industries and of the natural resources of the country. And organization of the whole requires unselfish service and devotion all around. The big metallurgical industries of this country have seen their duty and are doing it in placing war metals at the country's disposal at cost price. More than one chemical manufacturing plant that expects to be taken over by the Government as a whole is straining every nerve to deliver a working unit of highest efficiency and deepest loyalty. And so all of us must stand ready to serve our country with hearts and heads and hands and fortunes.

Steel in War

The United States enters the world war making steel ingots and castings at the rate of about 45,000,000 tons a year. When the war started the Central Powers had a capacity of about 22,000,000 tons, while the capacity of the United Kingdom, Canada, India, France, Belgium and Russia was a trifle less, and this capacity has been since materially reduced. Italy entered the war, it is true, with a capacity of about 1,000,000 tons, and England's capacity has been increased, but the Entente Allies lost all the Belgian capacity and most of the French, while it seems that Russia has not been able to operate at more than about two-thirds capacity. The Central Powers have hardly operated their original works at capacity, though they have probably gained considerable production in the occupied territory. At any rate the American capacity added on the side of the Entente Allies is overwhelming. We can make a much greater tonnage of steel than we can fabricate into things useful for war purposes, and it is in that direction that the strain will come. The supply of crude steel will take care of itself.

It was early recognized that this was a war of steel. Now it is a war of the steel nations. Save the Balkan states, and Portugal, which is only nominally in the war, there is not a country engaged in the war that has not a steel production somewhat commensurate with its

population. This appears a rather significant fact.

Of the remaining neutrals there are only two having steel production equal to that of even a modest-sized American works, Sweden, with a capacity of perhaps 600,000 tons, and China with perhaps 150,000 tons. Less than 1 per cent of the world's present steel production, which is running in the neighborhood of 85,000,000 tons a year, is being produced by nations at peace. Whatever may be the ability of the belligerents to rebuild and refurnish when the war ends, the neutral countries will certainly have to find means to buy a great deal of steel, for they can get very little at present.

For efficiency "all place a temple and all season summer" but this is a particularly ripe time for American efficiency. As to steel it is a question of finding means to fabricate as much as possible to the uses of war, when the supply of crude steel is virtually unlimited and some of the channels through which it flows into final form are painfully restricted. For much more than a year the plate mills have been congested with tonnage, most of the plates being wanted virtually for war purposes, so that it is not a case of setting an unimportant customer back that an important customer may be served.

When the final limit of the fabricating capacity for steel is reached, American ingenuity must find other patterns, equally useful, to make instead. If the shipyards are congested with the work of building vessels of the regular type, other types of vessels must be developed, that can be built with less equipment, using, if possible, rolled forms of steel that are not in acute demand for war purposes. The tube form is the strongest disposition of matter. Perhaps steel pipe, or certain merchant mill products, can be combined with wood for constructing vessels rapidly without the elaborate layout of the conventional shipyard.

From the "flivver" to the 60 or 80 miles an hour road burner our automobile factories are turning out internal combustion engines to the tune of more than 50,000,000 hp. per year, a magnificent factory equipment from which to draw engines that should be adaptable to thousands of small vessels for merchant, scout and other purposes. We have the iron, the steel and the equipment; it is a question of efficiency to develop and build from what we have.

A Suggestion on Fire Brick

Since the founding of this journal in 1902 it has ever tried to act as an intellectual clearing house for the metallurgical and chemical industry. Starting in the special domain of electrochemistry, it found at once one allied field of special importance thereto. This was the field of refractories, for in electric furnace work special brick must be used. In the abnormal period in which we have all lived in the past three years, an abnormal and unusual strain has been put on the manufacturers of refractories. Good and uniform clay deposits are not frequent. Furnaces have been "fired hard." Coal has been poor. Firebrick has sometimes been of poorer quality for these reasons and because it is so largely

a question of labor. All makes for an excess of consumption over production.

Such all being so plain as to rival the foremost feature of one's face, it seems that something must be done now. We venture a suggestion. We know that aluminium silicate when pure is a fine refractory. We also know that the fusible impurities of ordinary fire clay, viz.: Fe_2O_3 , CaO , Na_2O and K_2O are soluble in dilute hydrochloric acid. We further know that the advance in the state of the art in leaching and filtering is such that it is cheap and efficient from every standpoint on a basis of from 100 tons to 1000 tons per day.

Why not, then, leach, wash fireclay and so extract the impurities to a substantial degree? This would equalize impurities by large-scale mixing of the clay. The slight gelatinization of the silica would increase binding properties. The quality of bricks so made would be immensely improved and in short a firebrick of a very fine grade would be made.

In this age of hustle, bustle and worry quick results are needed. We recommend to one who can see this duty to do it. Firebrick and refractories having been a favorite field of this journal for many years, we believe that, to quote the words of the immortal Governor Jeremiah Rusk, in publishing this suggestion, "we seen our duty and we done it." But as a friend of the said governor stated, "It is a condition and not a theory that confronts" the firebrick manufacturer.

Switzerland and the Chemical Industry

In looking over the output of chemicals by Switzerland for the last two years, one wonders how under present circumstances it has been possible for any European country to show an increased output in any field of industrial manufacture outside of war supplies. And yet the export figures of Switzerland for the years 1914 and 1915 compare as follows:

	1914.	1915.
Chemicals for industrial purposes.	\$3,516,742	\$5,887,067
Paints, dyes and colors.	6,232,660	6,443,548
Pharmaceutical products, drugs		
perfumery	3,100,163	4,747,680

With only very few natural resources, the chemical industry in this small heart of continental Europe has steadily increased. Considering that salt, lime and asphalt are about all the raw materials available in Switzerland, the above figures are all the more remarkable. All other raw materials must come from the warring nations. This actually is the case; Germany supplies iron and coal, while England, Italy and France furnish most of the other raw materials.

There are two well-defined reasons why in the industrial field Switzerland is progressing in spite of the war: First, because it has a well-organized government whose sole ambition is the welfare of the country, and secondly because it would be of no advantage for either of the belligerents to antagonize Switzerland, as it has one of the most efficient armies in Europe.

Switzerland without its industries would undoubtedly starve or be forced to side with one or the other warring factions. While the Swiss industry as such is

undoubtedly developing very rapidly, the increased export values are, to a great extent, due to the fact that the other countries are exporting less of the same products.

The Late David H. Browne

"There are in every profession men whose personality and accomplishments raise them above the level of their colleagues and they in turn raise their profession to new standards and their conferees to their own level. . . . Such men create a new horizon, envisage large ideals, invest old things with a new meaning."

This quotation from David H. Browne's recent Mining and Metallurgical Society address on H. C. Hoover's work may well be applied to David H. Browne's own life that was cut short by an untimely death on March 30. In the obituary notice on another page of this issue mention is made of his two big metallurgical achievements—the development of his electrolytic process for separating the copper and nickel in Sudbury ore and the successful reduction to practice of powdered-coal firing of reverberatory smelting furnaces.

David H. Browne was a truly great metallurgist but he was even greater as a man and no one who once had the privilege of meeting him will ever forget him. The wonderful combination of straight common sense with lofty idealism, often flavored with quaint Irish humor, which was so characteristic of Browne as man, found vivid and true expression in the addresses made by him—a minister's son—on many a festival occasion.

From an address delivered by him before the Engineering Society of Queen's University in 1912 (this journal, vol. X, p. 393) on the real objects of university education—culture, friendship, inspiration—we quote the following passages:

"Culture, friendship, and inspiration, these three, and the greatest of these is inspiration. This is the one thing which all the others lead to, for this is the true vision. Inspiration means the inbreathing of a great spirit, the breath of fire in man's nostrils. We cannot define it, we cannot analyze it, we can only feel it as we feel a chord of music. It comes from the consciousness of the presence of the mighty dead who have molded the nation, it comes from the companionship of noble men and women living around us, from the memories with which the college halls are hallowed. You know the feeling that comes over you in a close-packed crowd when the leader arises and you see the tense upturned faces around you and hear the quick intake of breath, as the truth he speaks sinks home. You picture the gaunt figure of Lincoln at the National Cemetery and the hushed audience that hangs on his words as he gives them the greatest speech ever made in the English language, the matchless Gettysburg address. They turn away too deeply moved to applaud, too much uplifted to cheer, because they have received the inspiration, they have seen the vision."

David H. Browne has gone. But he is still with us: we have received the inspiration, we have seen the vision.

Readers' Views and Comments

Methyl Alcohol and Acetone as By-Products of the Soda Pulp Industry

To the Editor of *Metallurgical & Chemical Engineering*

SIR:—The publication of the interesting article by Professors White and Rue in your issue of Feb. 15 on the recovery of products from black liquor by destructive distillation coincides with the commercial development of a similar process which is now taking place in this country and on the Continent.

The peculiarity of the black liquor obtained at the mills here is, of course, that they are all obtained from cooking Esparto—no soda wood pulp being produced here.

A general outline of the complete process as used in handling the black liquor from the time it is drawn from digestors is as follows:

1. Continuous film evaporation in a "multiplex" triple effect where the liquor is brought to about 25 to 26 deg. Bé.
2. Evaporation in a pressure finishing evaporator to 38-40 deg. Bé, the vapors being used to partially operate the "multiplex" at 7 lb. back pressure.
3. Black syrupy liquor from finishing evaporator incorporated while hot with a measured quantity of lime hydrate and run into trays to the required depth.
4. Trays loaded on to trucks and placed in horizontal retort for carbonization.
5. Leaching the carbonaceous residue and recovering soda.

The theoretical process covering the production of acetone and wood alcohol by destructive distillation of black liquor mixed with lime was patented, we believe, by Dr. Rinman of Stockholm, whose experiments on both laboratory and commercial scales have proved the feasibility of the chemical manipulations and changes involved, so that the matter of constructing commercial equipment for carrying out the process most economically and to enable the operations to become profitable lay with ourselves as makers of chemical plant.

The patentee had constructed various sized units on the Continent for experimental processes, the most successful from an operating standpoint being a retort in the shape of a cone, down the sides of which the liquor flowed in a film, the carbonized mass being scraped off from time to time.

We, on the other hand, had built several plants for the production of acetone by the distillation of calcium acetate and knew the conditions under which most favorable results were obtained there. We had also built many plants for carbonizing wood to produce wood alcohol, and were acquainted with suitable conditions of operation in this work. We decided, therefore, to adopt our standard design of acetone plant from calcium acetate, to the carbonization of lime-black ash distillation.

It was necessary to limit the thickness of the layer of lime-black ash in each tray on account of its tendency to froth, but once the maximum thickness allowable was arrived at the determination of time and temperature required for distilling charges of several tons was a simple matter.

I notice that Professors White and Rue do not make reference to any peculiarity of their "tar" as obtained from wood pulp black liquor. One of the most interesting products from Esparto black liquor is the "tar" or the equivalent of tar. In reality the "tar" obtained in this case is a light brown wax which is quite hard

when cold, resembling greatly the "Candelilla wax" obtained from a plant (*Euphorbia antisiphilatica*) grown in Texas.

The condensation, therefore, of the wax and the separation of aqueous condensate from it, as well as the absorption of the ammonia produced in the distillation presented a unique problem. The difficulty was overcome by fractionally condensing the wax in a "pre-condenser" at approximately 200 deg. C., and allowing it to drain off in a molten state. The middle oils were fractionally condensed at 110 deg. C. and drawn off. Fortunately the oily wax seems to be a very homogeneous substance, practically all condensing at the two temperatures, allowing all the aqueous vapor with acetone, alcohol and ammonia to pass to the absorber where the latter is absorbed in sulphuric acid, the water alcohol and acetone going on to the final condenser.

The refining of the products is only carried to a point which makes them salable. The wax is drained and shipped as pressed cakes. The sulphate of ammonia liquor is shipped in casks to the tar works for evaporation. The acetone and alcohol are merely rectified together without attempting a separation, until a water-white miscible liquid is obtained testing about 95-97 deg. on Tralles hydrometer. This is marketed direct as "methyl-acetone" or "alcohol-ketone" for cellulose acetate solvent, etc.

As a matter of fact, it is doubtful if the amount of actual acetone as such produced is anywhere near the amount apparently present or determined by iodoform test. The "acetone" indicated in the mixture by the iodoform determination consists probably in large part of other ketones. We have never been able by the ordinary methods of rectification or chemical treatment to separate pure "Government Specification" acetone for explosive use from this product.

A description of the general arrangement of the retort and condensing plant may be of interest. The point of taking out the vapors from the retort was arrived at by trial, the point selected being the *coldest* part of the entire furnace. Ample arrangements are provided for pyrometer measurements at various points. Heat distribution and circulation *inside* the retort are provided by injecting a small amount of superheated steam at the correct temperature so that it comes in actual contact with the trays and their contents, sweeping the entire length of the retort to the exit pipe.

The working temperatures arrived at for maximum yields are below the limits of 288-316 deg. C., suggested by White and Rue, viz.: 255 to 300 deg. C.

The above results and conclusions are the result only of data obtained to date, and these statements should be considered as tentative only, as further data are being collected for a series of experiments which should indicate the effect of varying several factors in the process. We are of the opinion that the present yields must be increased by some 50-75 per cent to approach the theoretical, so there is room for a great deal of investigative effort in this connection.

BLACK LIQUOR DISTILLATION

(Percentages on actual liquor without lime)

Watery distillate	42.2 per cent
Wax and oils.....	6.0 per cent
Ammonia	0.3 per cent
Residue	40.7 per cent as black ash only
Gas	10.8 per cent

Watery distillate: Spirit content, 5.24 per cent.
 Spirit test: 70 per cent methyl alcohol; 30 per cent acetone, ketones and aldehydes.

Wax and oils: Wax, 39.2 per cent, condensed at 200 deg. C in pre-condenser.

Middle oils, 56.5 per cent, condensed at 110 deg. C. in second condenser.

Light oils, 4.3 per cent, condensed with watery distillate.

From our results to date we seem to be in agreement with the essential points of Messrs. White and Rue's chemical and financial deductions in so far as the two raw materials allow of direct comparison. Their credit of methyl alcohol and acetone mixture of 95 per cent strength at a pre-war price of only 40 cents per gallon is most conservative, as the writer was selling similar material in the U. S. A. at 60 cents naked at works in 1913-14. With the production of wax instead of tar the income in Great Britain is considerably increased, but we are of the opinion that the tar as produced from wood liquor containing upwards of 50 per cent phenols, as stated, should bring a good price raw, but better if worked up at the factory.

On the whole, our experience so far leads us to believe that in the U. S. A. the figure of \$1.86 net saving per cord of wood treated in the digester should be slightly exceeded in normal times. At the present time, of course, with products bringing abnormal prices, the net return should be considerably above that.

JAS. C. LAWRENCE.

Blair, Campbell & McLean, Ltd.,
 Glasgow, Scotland.

Ball Mills

To the Editor of Metallurgical & Chemical Engineering

SIR:—Referring to the publication in your issue of March 15 of the informal paper by Mr. Marcy on "Marcy Ball Mills" read at the February meeting of the Mining and Metallurgical Society of America, but not printed in the *Transactions* of the society, I am mainly interested in the errors and omissions of the article mentioned, and Mr. Marcy's remarks relative to the Hardinge conical mill, to which he refers as the "cone mill." I ask a little space, in justice, not only to myself, but to Mr. J. M. Callow, the Miami Copper Company, and the Inspiration Consolidated Copper Company, as well as the metallurgist who is seeking facts.

The Hardinge mill to which Mr. Marcy refers and which was used by Mr. Callow in 1912, was a 6 ft. diameter by 16-in. length of cylinder conical ball-pebble mill such as is now used for fine grinding only. The results of this work were open to observation of the Miami Company's engineers and were such that they conceived the possibility of replacing their fine rolls with Hardinge ball mills. The one referred to by Mr. Marcy was accordingly installed and a test run of approximately 25,000 tons of ore resulted in the opinion at that time that the rolls already installed were doing fairly comparable work, and the test was discontinued.

After continuing the operation of the rolls for over three years and gaining data through their operation, and comparing same with the results of their first test with the Hardinge ball mill above cited, and finding it far superior to the work of the rolls for present requirements, they have recently placed an order for eight standard 8-ft. diameter by 30-in. cylinder Hardinge ball mills to take the coarse feed which at the present time is being fed to their secondary rolls. An action such as this, under the guidance of the Miami's critical engineering staff, who are seeking the highest efficiency, is an obvious recommendation and adoption of the system which Mr. Marcy points to as a "failure." It was a

failure at that time only because comparative data were lacking.

Still further emphasis is given to their opinion in view of the fact that the Miami Copper Company adjoins that of the Inspiration and both companies are working upon identically the same ore body. Further, the Inspiration Copper Company, after having presented to them data and the comparison of their work with Marcy mills and the work of the Hardinge mills at the Miami Copper Company, as well as other comparative facts and figures, are at the present writing installing Hardinge mills in the newest section of their plant. Up to the present time they have never previously had a comparison between the Hardinge ball mill and the Marcy ball mill, the latter equipped with 225-hp. motors, the motors absorbing approximately 240 hp. each.

These 8-ft. diameter by 36-in. cylinder Hardinge ball mills are being equipped with 150-hp. motors, will contain a greater charge of balls than the Marcy mill, but will operate with approximately 100 hp. less than is being absorbed by each of the Marcy mills now in operation. Relative capacities, horsepower, and general efficiency will no doubt affect the final decision and ultimate final reconstruction of the Inspiration plant. The management gave it as their opinion that we would require motors of equal size as those used on the Marcy mills (225 hp.). Upon showing them facts and figures they consented to the adoption of motors of 150 hp., which we consider to be ample for the requirements.

Mr. Marcy has overlooked in his paper information which was presented at the American Institute meeting in Arizona in 1916, relative to operating costs, including the consumption of chrome steel balls per ton of ore crushed. Permit me to supply the oversight and add the consumption of balls in the case of this "successful failure" (?) to use Hardinge conical mills. This ball consumption, however, should only be taken into account provided the comparison by Mr. Marcy can be made at all, which I do not believe to be the case and which I claim is unfair to all concerned, as all the grinding requirements should be considered:

	Chrome Steel Balls Per Ton Ore
Marcy Mills at Inspiration plant.....	1.79 lb.
Hardinge Conical Mill at Callow test.....	0.75 lb.
Hardinge Conical Mill at Miami test.....	0.58 lb.

As Mr. Marcy has undertaken to compare these "cone ball mills" at the Callow test plant at Inspiration, as well as the Miami plant, permit me to supply omissions and give below exact operating figures which I am ready to verify. These three mills were all working on the same class of ore, from the same general ore body, but in adjoining claims, and the ore was generally relative as to the size of feed and discharge. The following results are of interest to your readers:

	Horse- power	Tons Per Day	Tons Per Hp. Day
6 ft. x 16 in. Hardinge ball-pebble mill in Callow test plant.....	40	386	9.64
6 ft. x 16 in. Hardinge standard, ball mill in Miami test plant.....	35	351	10.03
Marcy No. 85 ball mill in Inspiration test plant.....	138	628	4.55

Mr. Marcy refers to "1100 tons per day" in his largest mill at the Inspiration plant, in which case the feed is slightly coarser than in the above mentioned tests. We are also able to supply Mr. Marcy's omission as to the power required by this mill:

	Horse- power	Tons Per Day	Tons Per Hp. Day
Marcy No. 86 ball mill.....	230	1,100 (?)	4.78

It is worthy of note that the Hardinge mill is approximately 100 per cent more efficient, measured in tons per

horsepower-day, than is the Marcy mill, based on Mr. Marcy's own figures and comparisons, but without data.

These and other data when presented to the Inspiration engineers, tabulated, and considered by them, have resulted in the installation of Hardinge ball mills in the last and newest section of the Inspiration plant, the operation of which has been delayed by the non-receipt of other machinery to complete the installation.

H. W. HARDINGE.

Hardinge Conical Mill Co.,
New York City.

Vanadium Check in High-Speed Steel Analysis

To the Editor of Metallurgical & Chemical Engineering

SIR:—The result of a vanadium titration according to Dr. Johnson's modification for high-speed steels can be rapidly and accurately checked by the following method:

Upon taking the final reading of the vanadium titration, immediately add an excess of permanganate solution and stir vigorously for half a minute to insure complete reoxidation of both the vanadium and the ferrous ferricyanide precipitate. Next add the standard sulphate solution at a rate of about one drop per second, stirring rapidly in alternate directions, until the last pink tinge disappears. This point is easily arrived at by a practiced operator, viewing the solution through the side of the beaker placed before a window. At the critical point the addition of one or two drops fades the last pink and leaves a clear yellow solution. At this stage take the reading and titrate as before.

The following checks obtained by the writer verify the accuracy of the method:

% V found	Check
0.91	0.92
.83	.83
.67	.67
.21	.23
.18	.16

In the first reduction of the chromium and vanadium, it is desirable to add at least 4 c.c. excess of the sulphate solution.

The addition of the iron solution for each of the titrations, should be made at the same rate of speed.

EDWARD C. KRAUS.

Dunkirk, N. Y.

Big American Dyestuff Companies Merge

The two largest dyestuff companies in the United States, the Schoellkopf Aniline and Chemical Works, of Buffalo, and the Beckers' Aniline and Chemical Works, of Brooklyn, have planned to consolidate under the name of the National Aniline and Chemical Company, Inc. The capitalization of the new concern is expected to be close to \$20,000,000.

The Schoellkopf Company is the oldest and largest of the American dyestuffs companies and has expanded rapidly since the outbreak of the war. It has an enormous plant at Buffalo, the output of which has been sold by the National Aniline and Chemical Company, of 100 William Street, New York. The Schoellkopf Company is capitalized at \$3,000,000 and controls the selling company which is capitalized at \$1,000,000.

The Beckers' Company has also expanded rapidly since the war and is at present capitalized at \$5,000,000. It recently concluded the purchase for \$2,500,000 of the Standard Aniline Products Company, which has plants at Newburg, N. Y., and Wappinger Falls, N. Y.

The consolidation is significant for the dyestuff industry in this country and should place the new company in a strong position to meet competition. It is also the intention to manufacture pharmaceuticals and photographic chemicals.

Coming Meetings and Events

American Electrochemical Society, spring meeting, Detroit, Mich., May 2-5, 1917.

American Iron and Steel Institute, New York, May 25-26, 1917.

American Society for Testing Materials, Atlantic City, June 26-30, 1917.

Third National Exposition of Chemical Industries, Grand Central Palace, New York, week of Sept. 24, 1917.

American Institute of Metals and Foundrymen's Association, Boston, week of Sept. 24, 1917.

American Electrochemical Society, autumn meeting, Pittsburgh, Oct. 3-6, 1917.

American Institute of Mining Engineers, annual meeting, St. Louis, Oct. 8-13, 1917.

The Western Metallurgical Field

Flotation in Canada

Oil flotation is on a solid footing in the Cobalt District of Ontario. At the present time five mills are in operation with an aggregate tonnage of 1300 tons daily. These mills are the Buffalo with a capacity of 600 tons, which started operation during the earlier part of October; the McKinley-Darragh, 100 tons, which began operation in July; the Northern Customs, 100 tons, operating since the beginning of November; the Dominion Reduction, 200 tons, working since the earlier part of December, and the experimental plant of the Nipissing, 300 tons, which opened operation in June. In addition to the mills mentioned, it is expected that at least two more installations will be operating within the month, namely, the Coniagias and the National. The daily output will be 150 and 75 tons respectively.

Cyanide

Sodium cyanide has now entirely replaced potassium cyanide for the recovery of precious metals in fumigating, plating, etc., the results proving equal if not superior to those obtained by the use of potassium cyanide. Another element of saving is the lower cost of transportation in so far as the cyanogen content of sodium cyanide is greater than that of potassium cyanide.

One of the chief producers of cyanide offers the following products for sale: Sodium cyanide, 96 to 98 per cent, with a cyanogen content of 51 to 52 per cent; sodium cyanide, 89 to 91 per cent, cyanogen content 48 per cent, and cyanide chloride mixture, sodium cyanide, 73 to 76 per cent, and a cyanogen content of 48 per cent. It is noted with pleasure that the sodium cyanide present is given as such, and not in terms of potassium cyanide, as has been customary.

Radium Plant in Colorado

The Schlesinger Radium Company of Denver, Col., has acquired interests in some of the leading radium-ore-producing mines in both Colorado and Utah. In 1915 this plant was in an experimental stage. Since then operations have developed steadily and at the present time the rate of production is three grams of radium element per year.

The company is developing several branches of its business, one being the successful production of the by-products of radium-bearing ores, namely the manufacture of vanadium and uranium compounds from carnotite ores. One of the most interesting features is the manufacture of radio-luminous paint. This material gives off light in darkness through the stimulating effect of radium. It is found permanent for all practical purposes. The paint will be used for illuminating the fig-

ures on watches, on clock dials and on house numbers. This product is turned over to the Cold Light Manufacturing Company of Denver, which is exploiting further uses for the material. The United States government is using the luminous paint on compass and aeroplane dials.

The research laboratories connected with the Schlesinger Radium Company are at present undertaking the very interesting work of establishing an actual standard for the luminosity of the luminous products. This work is needed badly in order to standardize the materials sold on the market and to prevent the marketing of substitutes which are valueless.

Tungsten

Tungstic Acid Made in Colorado.—Within the past year two companies have entered the field of manufacturing tungstic acid WO_3 in Colorado. These are the Tungsten Products Company and the Black Metal Reduction Company, both situated at Boulder. At the present time both companies forbid the inspection of their plants, and while one may surmise the processes used, no definite statements concerning them can be made.

The Black Metal Reduction Company is turning out 600 lb. of tungstic acid daily of a very high degree of purity. An interesting feature in the manufacture of tungstic acid by this company is that the product marketed is obtained by a straight process without further refining. It is unfused and its purity ranges from 99 to 99.7 per cent WO_3 . Only 0.25 per cent of the acid is insoluble in ammonia. It is worthy of notice that the product is very low in sulphur and phosphorus, the maximum permissible amount being 0.04 per cent of each. The analysis of some of the materials gave not the slightest indication of the presence of sulphur and phosphorus. The moisture content of the product is 7.2 per cent. The main impurities, occurring in minimal amounts only, are iron and manganese. The total output for a period well into the future has been contracted for by eastern brokerage concerns. Any tungsten-bearing ore or material is used as a starting point. At present tailings are treated which are bought on the basis of their tungstic acid content.

Little is known of the doings of the Tungsten Production Company beyond the fact that they are making tungstic acid and ferrotungsten. The latter product is made in an electric furnace and considerable attention is being paid to the production of a product with a minimum amount of carbon and with a high tungsten content.

Buying Tungsten Ores.—In Boulder County, Colorado, two schedules for purchasing tungsten ores are used, one being based on the tungstic acid content per unit and the other on the tungstic acid content per pound. The pound schedule is generally used; however, two of the largest companies, the Primos Chemical Company and the Rare Metals Ore Company, buy their ores by the unit content, paying \$10 per unit up to 40 per cent WO_3 . It is claimed that the latter scheme is more readily understood by the miner and offers him a better price. On the other hand, the users of the pound schedule claim that both schedules are about the same, the difference between the two being so small as to be negligible. The base of the price is a sliding scale depending on the mill saving. At present the base employed by one of the producers is \$15 per unit of 60 per cent WO_3 product.

No penalties are charged and no premiums are given. This condition is a source of annoyance to the mill man, as at times a mineral is present which increases the tungsten losses and reduces the grade of the concen-

trates. This mineral is known as "horn rock" in the district. In reality it is a jasper, the coloring ingredient of which is tungsten instead of iron. This mineral is very light and much is carried off during milling, nevertheless a certain percentage of the impure material enters the concentrates and lowers the grade of the same. The mill men are therefore in favor of penalizing ores carrying above a certain percentage of horn rock.

Company Reports

Tonopah Belmont Development Company.—In the thirteenth annual report of said company the following items are of interest: The Tonopah plant at Tonopah, Nev., has been in continuous operation throughout the year, that is from Feb. 29, 1915, to the same date 1916, on Belmont mine ores. During this period 165,157 dry tons of ore, containing 32,348,289 ounces of gold and 3,237,602.06 ounces of silver were milled. The average grade of the tonnage treated was 0.196 ounces of gold and 19.603 ounces of silver, or \$13.883 per ton. The gross value was \$2,292,943.06, calculated silver in bullion at 50 cents per ounce. The average value per ton was lower than the per ton value of the previous year, which was \$16,721, by \$2,838 per ton, or by approximately 17 per cent.

The average recovery of gold was 96.18 per cent, while that of silver was 91.69 per cent. The combined gold and silver extraction was 92.97 per cent as compared with 92.99 per cent for the last year. The tailings for the year averaged 0.0075 ounces of gold and 1.63 ounces of silver. This is equivalent to \$0.964 per ton as compared with \$1.168 for the previous year (gold calculated at \$20 per ounce and silver at 50 cents per ounce). The average daily tonnage treated over a period of 361 days was 457.5 tons.

The average direct milling cost was \$2.366 per ton, or \$0.210 per ton higher than the similar cost for the preceding year. The average indirect milling cost was \$0.316 per ton, or \$0.092 per ton lower than that of the previous year. The average total milling cost was \$2.682 as compared with \$2.564 for the same item the year before. The direct cost of production of the unit ounce of Doré bullion was \$0.13 as compared with \$0.104 for the previous year. The higher costs per ton and per ounce of metals produced were due to the smaller tonnage handled, and to the increased cost of chemicals and other supplies.

The Millers plant, at Millers, Nev., was operated throughout the year as a custom mill. During the year it treated 56,730 dry tons of ore averaging 0.309 ounces of gold and 25.01 ounces of silver. The gross value of the material treated was \$1,073,516.86. The gold recovery was 93.75 per cent, while that of silver amounted to 90.13 per cent. The combined extraction of gold and silver was 91.33 per cent as compared with 87.98 per cent for the year previous. The yearly total profit amounted to \$33,397.96.

The average direct milling cost was \$3.57 per ton as compared with \$3.796 for the preceding year. The average indirect milling cost was \$0.228 per ton, as compared with \$0.277 per ton for the year before. The average total milling cost per ton of \$3.798 shows a reduction of \$0.275 per ton from the similar cost of the previous year. The direct cost of production of the ounce of Doré bullion was \$0.156, showing a reduction of \$0.006 per ounce over the same item of last year. The increased recoveries and decreased costs were due almost entirely to the installation of the continuous decantation system during the previous year. The cost of this installation amounted to \$24,930.10, which was completely refunded during the course of the year.

During the year 1,018.07 tons of "sweepings" have

been recovered under a leasing system, from the impounded Tonopah tailings. The average value per ton of this material was 0.343 ounces of gold and 55.92 ounces of silver, or a total gross value of \$34,328.28. The net returns from the "sweepings" was \$4,836.21. Because of the exorbitant smelter charges on this fine material the company has decided to erect a small mill to handle the product, as it cannot be treated satisfactorily in connection with the ores handled at the mill. The cost of this small plant will be less than \$10,000.

The Training and the Work of the Chemical Engineer

Symposium Before Faraday Society

The Training and Work of the Chemical Engineer was the subject of a symposium of papers and general discussion before the Faraday Society in London on March 6, 1917.

Sir Robert Hadfield, president, was in the chair, and in introducing the subject he indicated how wide a field of work was covered by the industrial chemist, and therefore early in his training he should begin to branch off into the line of work with which he would afterwards be associated. After giving some amusing personal incidents illustrating the kind of early training he himself had received, the president made reference to what was now being done in Great Britain by the government to aid industrial research. Finally, he outlined the scheme recently proposed by the Ramsay Memorial Fund for promoting chemical training and research in memory of one of the greatest English chemists, a scheme which included the establishment of a Ramsay Memorial Laboratory for dealing with the very subject they were discussing, namely, engineering chemistry.

THE FUNCTION OF CHEMICAL ENGINEERING

Sir George Beilby presented the opening address in the symposium. At the outset he referred to the great danger that war conditions might encourage the development of unbalanced proposals for the training of the future leaders and workers in industry. Free exchange of opinion should be proof against such a danger.

He then defined the subject as follows: *Chemical engineering has for its function the design and construction of apparatus required for the carrying out of chemical processes on a manufacturing scale.* Carefully distinguishing between the work of the research laboratory, of the process control laboratory, and of the works proper, and remarking that laboratory training alone tends to produce a certain narrow individualism, he summarized as follows a scheme for the training of chemists for industry:

1. A sound and practical training in chemistry and chemical physics extending over three years. During the third year special subjects to be introduced.
2. At the end of the third year at latest the case of each student to be considered by the heads of the departments, so that he may be advised in what direction he should specialize.
3. Average students with no special bent to complete their course by general advanced studies during the fourth year.
4. No degree or "hall-mark" to be given in chemistry till the complete four years' curriculum has been taken.
5. Chemical engineers, research chemists, and specialists in other branches to devote one or two years to higher post-graduate study.

He next illustrated the special engineering knowledge and experience required by the chemical engineer, due

to the wide variations in the conditions under which chemical processes take place. Finally, he defined the difference between the point of view of the chemist, who viewed matter as made up of molecules, and of the engineer, who dealt with matter and energy in the mass. As the point of view of the engineer was not so far removed from that of the ordinary intelligent person, it was often very difficult for him to look at chemical problems from the chemist's standpoint. Hence it was wiser first to imbue the mind of the student with the more difficult, because less ordinary, point of view.

THE TRAINING OF THE CHEMICAL STUDENT FOR WORK IN THE FACTORY

Professor F. G. Donnan, in speaking on this subject, classified chemists as follows:

CLASS I. *Chemists* (Research Chemists).

CLASS II. *Engineer-Chemists.*

CLASS III. *Chemical Engineers.*

Up to the present our tendency has been to keep the chemist and engineer apart; in the author's opinion this has resulted in grave loss of efficiency. For the successful development of a new process after the chemists of the research department have worked it out in the laboratory, men of Classes II and III should combine to design and test a small trial plant in order to obtain special chemical engineering data, and all three should then combine to deal with a technical unit plant, fully working out in particular the thermophysics, the thermochemistry, and the thermodynamics of the process.

Class I men are the discoverers of new compounds and reactions, and must be men of wide outlook. In addition to their chemical knowledge they must be trained in physics and physical chemistry and have some idea of engineering science, so as to be able to co-operate intelligently with Classes II and III. Men of Class II, who are required in far greater numbers, should receive a considerable amount of somewhat specialized engineering training, the outlines of which are indicated. Certain qualities of *temperament* too are essential. Men of Class III must be thoroughly trained engineers above all; the more chemistry they know the better.

To our standard schools and institutions of civil, mechanical, electrical, heating, illuminating, and aeronautical engineers we must add without delay schools and institutions of chemical engineering.

Just as the culmination of the training of chemists must be research, so must that of the engineer-chemist, but it must be research on some chemical process on a technical scale. For this purpose cheap, rough laboratories should be erected, and the work must be quantitative as regards materials, energy and cost. The work of the engineer-chemist is essentially *applied physical chemistry*.

THE FORGOTTEN FACTOR IN CHEMICAL TRAINING

Mr. W. R. Cooper presented "a plea for the forgotten factor in chemical training." However perfectly the theoretical and technical knowledge of the young chemist may be developed during his training, the all-important economic factor is wholly neglected—will any particular process pay? The idea of introducing the factor of cost is often distasteful to the teacher. Yet the results obtained regardless of cost are of no commercial value, and a commercial problem is on no lower a plane than one purely scientific, for it includes an additional factor and is more difficult of solution. In a large works the young chemist might pick up the necessary economic knowledge, but in small works this is unlikely, and in any case guidance is desirable and would prevent many unsound chemical processes being put forward.

THE TRAINING OF THE WORKS CHEMIST IN PHYSICS

Mr. Charles R. Darling described the course of physics which chemical students take at the City and Guilds Technical College, Finsbury, aggregating over the three years about a hundred and twenty lectures and two hundred hours' laboratory work. The course in sound is confined to twelve lectures; that in light includes the principles underlying and the manipulation of the instruments commonly used in chemical practice; that in heat also has special reference to technical applications, including, for example, fuels, electric furnaces, pyrometry, refrigerating machinery, and so forth.

COLLEGE TRAINING OF CHEMICAL ENGINEERS

Mr. J. W. Hinchley described "The Work of the Imperial College in the Training of Chemical Engineers." The Department of Chemical Technology was inaugurated in 1912 under the direction of Professor W. A. Bone, and the teaching of chemical engineering, for which the author is responsible, is being developed as part of a larger scheme of post-graduate study and research in chemical technology. The principal features of the course are outlined. The student has to compile a reference book from which he can at once obtain quantitative information on the subjects he has studied, such as the properties of steam, rates of evaporation from liquid surfaces, loss of heat from surfaces, and so on. He is taught the most efficient methods of calculation and how to handle technical problems too involved for exact treatment. He makes drawings of tanks, condensers, etc., and experimentally studies units of plant like filter presses, reaction towers, stills, and grinding mills. He makes original designs of simple plant for a given output of product and determines therefrom and from experimental data the cost of production of the product. The training is not intended to take the place of factory training, but to plant the seed which, with experience, will grow to wisdom. The author opposes the view that chemistry and engineering are antipodal in character.

GENERAL DISCUSSION

First a number of written contributions to the discussions were read.

Mr. G. S. Albright, in emphasizing the difference between laboratory work and works practice, pointed out that a more minute and careful study of *all the conditions* governing an experiment in the laboratory might save many mistakes outside. He was strongly impressed with the necessity to the chemist of some engineering knowledge, so that he should not be wholly at the mercy of the works engineer.

Mr. E. B. R. Prideaux thought the smaller universities might, in co-operation with local manufacturers, differentiate their courses so as to supply a sound training for a works chemist. This would involve a free application of the methods of practical physics and of physical chemistry.

Mr. H. L. Heathcote wrote that in future training for the works must be *induced* by the needs of industrial processes, with their necessary limitations, rather than *forced* by the examination syllabus and academic atmosphere. He dwelt on the difficulties in assimilating or in turning to practical account the ideas of the scientific staff that obtained in practice on account of the inevitable constitution of the works and the limitations imposed by labor and material. Schemes for education and research should bear in mind these practical limitations and the science-man must be trained to overcome them. He must be a synthesist as well as an analyst.

Dr. P. E. Spielmann wrote that only a very excep-

tional man could combine in himself the knowledge and experience of both a highly skilled chemist and a fully qualified engineer. They ought, however, to aim at a training that would enable the chemist to criticize the engineer's drawings and the engineer to grasp the chemist's requirements.

Mr. Francis H. Carr also thought it rare to meet men endowed with both chemical and engineering sensitiveness, but more men with the combined aptitudes could be discovered and developed, and one great object of college training should be the discovery of the student's potentialities. Such complex chemical manufactures as have been developed here are due to men who have been trained in or had aptitude for both chemistry and engineering. The pure chemist is often timid in attacking practical problems outside the laboratory. He advocated the establishment in colleges of a department which could be conducted something like a factory, carrying on side by side with lectures the production, say, of fine chemicals (that have hitherto been produced in Germany) on the scale of technical experiments. He submitted these proposals for serious consideration.

The subject was then thrown open for general discussion from the floor.

Sir A. McDougall Duckham supported from his personal practical experience Professor Donnan's definition of the types of chemists and engineer-chemists required by industry. He went farther, and thought chemistry should be brought into every engineering course. He insisted on the importance of bringing the practical men and the practical work of the works into the colleges, and he thought also that students should enter works before college.

Professor A. K. Huntington remarked that although a thing in a works was useless unless it could be done economically, it must be borne in mind that what does not pay to-day may very well pay under different conditions or with increased knowledge; the Haber process, which the Germans were carrying out on a huge scale, was a case in point. He suggested the use of the term "works engineer" to indicate the man trained to deal with works processes. A great difficulty at present in the training of technical students was the miserable equipment, especially in mathematics, received in the secondary school. He concluded with an appeal to the scientific man to enter the works and so, by acquiring really adequate data, ensure theory working out in practice.

Mr. A. P. M. Fleming spoke of the importance of the engineer-chemist acquiring his experience in the works, and in this connection commented on the scheme for training industrial chemists at the Massachusetts Institute of Technology that Professor Donnan had outlined, in which third-year selected men were put into, say, Portland cement works, or electrochemical or gas or alkali works, to enable them to pick up Mr. Cooper's "forgotten factor." A further part of the plan was to organize at headquarters schemes of research in connection with each of the industries. He gave some interesting details of some of the post-graduate industrial research being carried out in America, and thought the universities here should develop similar schemes. Most important of all was to attract the best brains of the country into their profession.

Dr. W. Rosenhain emphasized the importance of breadth of view in the training of the technical man, which would enable him to face problems from many points of view. The simplification in conditions which was the essence of scientific research might be a drawback when dealing with practical problems, and hence the narrow expert would fail where the man of broad

insight would succeed. But the man with scientific training is the man who is bound in the end to "make good," provided he is satisfactory material to begin with.

Dr. R. Robertson thought the teaching of engineering to chemists essential, not only for its inherent value, but because it might be used by the professor as a touchstone to determine a student's true vocation—whether for pure research or applied science. He too agreed with the necessity for the student of contact with the reality of the works.

Mr. W. Macnab spoke of the opportunity present circumstances afforded of putting into practice some of the excellent teaching they had heard propounded during the discussion. There was a sad lack of engineering chemists in the country. A hopeful sign was the breaking down of watertight compartments of knowledge.

Professor E. G. Coker said there was often difficulty in placing young engineers with more brains than money in suitable positions, and he hoped for the general adoption of plans like that of Mr. Fleming. It must not be forgotten that many good chemists were not interested in engineering, and the reverse was also true, so that any educational scheme must be permissive. Courses of engineering for chemists should be specialized; much of the ordinary engineering could not possibly be of interest to chemists. He thought some of the American courses erred on the side of overloading, and preferred the English method of taking fewer subjects and doing them very thoroughly.

Lieutenant H. C. Greenwood thought it lamentable that the process chemist should often have no share in the erection of the plant. The remedy may lie in better education, but early specialization was generally a mistake, as students do not know what branch they will take up. While engineering in the way suggested by Professor Donnan must be taught, more prominence should also be given to pure physical chemistry, which was becoming of increasing practical importance.

Mr. C. S. Garland spoke of the gain to chemists and to industry to be derived from enlarging their view by training in engineering and works experience. Sufficient inducement could be relied upon to bring the right men forward.

Dr. E. F. Armstrong, while expressing his agreement with Sir George Beilby and Professor Donnan, did not think we had a shortage of plant chemists, who had been produced in goodly numbers by the universities. Moreover, after all, what chemical industry chiefly wanted was *chemists* first and then engineering chemists to tell the engineer what was wanted. While the works knows all about costs and management, it does not know, or is too busy to keep in touch with, modern developments in chemistry. To give an example: a man specially expert in the phase rule or colloidal chemistry put into a works might revolutionize many an existing process. Such men must be produced, and to do so not only must the university enter the works, but the manufacturer must enter the university, advise it, and support it. He did not altogether believe in the deficiencies of British chemical industry. The three great achievements in industrial chemistry in the last twenty years were artificial silk, fat-hardening, and synthetic ammonia. The last did not appeal to the British (before the war) because they had plenty of ammonia, but the first was an English achievement, discovered by an Englishman, Mr. Cross, and the second was largely worked out in Great Britain.

Mr. W. Gathorne Young thought the meeting would be an epoch-marking one and that the procedure should be along the lines marked out by Professor Donnan. After the first three years of training, only those

students should take a course in chemical engineering who showed an aptitude for it. The course should include systematic visits, with demonstrations, to chemical works and vacation work at such factories. Manufacturers would co-operate if approached in the right spirit. He did not believe manufacturing processes could be taught by operating miniature plant in the laboratory. If some of the best brains have gone into other professions during the past thirty years, it is because of the miserable return that has been offered to chemists.

Mr. T. G. Elliott agreed with those speakers who had laid stress on our general want of secondary education. He thought Professor Donnan's scheme rather academic, and dwelt on the value of the university to a district when it specialized in the work of the district, such as had been done by Sheffield University, for example.

Owing to the lateness of the hour the continuation of the discussion was then deferred to another meeting.

Preparedness Census of Technical Men

At the request of the Council of National Defense, the Bureau of Mines, Department of the Interior, has undertaken a census of mining engineers, metallurgists and chemists, with the view of ascertaining the qualifications of each and the line of work in which each could be of most service to the country in time of emergency. This work is being conducted in co-operation with the American Institute of Mining Engineers and the American Chemical Society. Circular letters are being sent to about 10,000 chemists who are members of the American Chemical Society and 5000 to mining engineers and metallurgists who are members of the American Institute of Mining Engineers.

While there are a large number of mining engineers and chemists who are not members of either of these societies, an effort will be made to obtain as complete a list of these as possible. This will be done by circularizing 4500 metal-mine operators and 4000 coal-mine operators, asking that they furnish the names of mining engineers, chemists, and metallurgists in their employ. These names will be checked against the list of the two societies named, and those whose names do not appear as members of the societies will be sent a special letter asking that they furnish the bureau with a record of their experience.

The results to be obtained by this census may be briefly stated as follows: It will make available for use a classified list of chemists, mining engineers, and metallurgists. The classification will embrace twenty-seven specific groups of industrial chemists, as explosives, sanitation, foods, dyestuffs, coal, petroleum, fats and soap, sugar, etc. The mining engineers will be divided into sixteen groups of engineering work, as for example: Engineers familiar with machinery construction, building construction, dredging, drainage and pumping, underground mining, shaft sinking under compressed air, etc. The classification of metallurgists will embrace fifteen groups, as for example, alloys, chromium and manganese, copper, lead, iron and steel, zinc, etc.

By such a minute classification the bureau will be in a position to furnish on a short notice the names of specialists, as for example, alloy metallurgists, food chemists, coal or iron mining engineers, or specialists in any branch of the mineral industry, so that in case of necessity these technical men could be placed in industrial plants where they would be of most assistance to the country. Experience in foreign countries has shown that the technical men were able to render vastly

greater assistance by being placed in the factories than in the regular army.

In addition to the technical classification, there will also be a classification of engineers, metallurgists and chemists according to their experience in foreign countries and languages with which they are familiar.

It is hoped that as a patriotic duty each engineer, metallurgist and chemist receiving these cards will furnish the information promptly, in order that the bureau may complete its work with the least possible delay. Complying with these requests in no way obligates the person who signs it, but has the advantage that in case of need he can be placed where his efforts will yield the best results.

David H. Browne

David H. Browne, chief metallurgist of the International Nickel Company, died on March 30, 1917, at his home in Montclair, N. J., after a short illness at the age of fifty-two.

He was born in 1864 at Hollymount, County Mayo, Ireland, and received his early education at the Londonderry Academy. At the age of sixteen he came to the United States and entered the University of Michigan, graduating in 1885. Following employment as a chemist at various metallurgical plants, Mr. Browne returned



DAVID H. BROWNE

to the University of Michigan and served as instructor in inorganic analytical chemistry in 1888 and 1889. When the Canadian Copper Company was organized he entered its service and was connected with it until it was absorbed by the International Nickel Company, the staff of which Mr. Browne joined. Most of his professional life he spent at Sudbury, Ont., but in 1914 he was transferred to the head office of the International Nickel Company in New York.

Mr. Browne's first big achievement was the development of his electrolytic process for the separation of nickel and copper in Sudbury ore, which was described in detail in our Vol. I, page 381 (see also Mr. Browne's articles on certain technical phases of this work in our Vol. I, pages 273 and 348). This process was in successful commercial operation for several years, but when the Canadian Copper Company was absorbed by the Inter-

national Nickel Company the process was abandoned in favor of the cheaper Oxford process owned by the latter company.

The second big achievement of Mr. Browne was the successful reduction to practice of powdered-coal firing of reverberatory smelting furnaces. This he was the first to do successfully on a large scale at Sudbury, and he freely gave full information of the success obtained and the means employed to others to follow suit.

In 1916 the honorary degree of Doctor of Laws was conferred on him by Queens University.

Mr. Browne is survived by his widow and three sons.

An appreciation of David H. Browne as a man will be found in an editorial on page 415 of this issue.

Annual Meeting of American Chemical Society at Kansas City

(By Telegraph)

The annual spring meeting of the American Chemical Society was opened on Tuesday evening, April 10, at the Hotel Muehlebach, Kansas City, Mo. About 335 members were registered at the opening of the meeting.

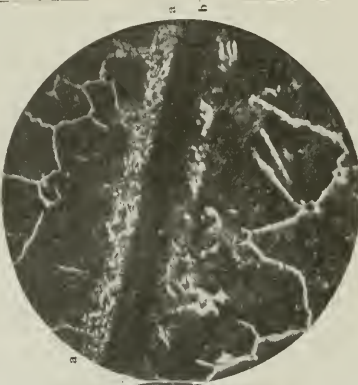
A dinner was tendered to the Council at 6.15 p.m. at the University Club, by the Kansas City Section. After the dinner the Council held a meeting in the assembly room of the Muehlebach. The report of the Committee on Co-operation of Universities and Industries and of the Committee on Analysis of Chemical Reagents were taken up. A resolution was adopted that local sections of the society shall have no authority to publish or issue resolutions representing official action of the society on national questions. It was decided to hold the next meeting in Boston during the week of Sept. 10, 1917. A committee was appointed to act on behalf of the society in questions pertaining to the present national crisis.

On Wednesday morning a general meeting was held in the hotel. The meeting was opened by Prof. W. A. WHITAKER of the University of Kansas. Mayor EDWARDS was scheduled to speak, but was unable to be present. He sent a representative, who welcomed the society to the City. Dr. FRANK STRONG, chancellor of the University of Kansas, delivered the opening address on "What War Means to College Men." Dr. JULIUS STIEGLITZ, president of the society, responded, and said that the society could aid greatly in the crisis by seeing that things are conducted scientifically and efficiently. Chemical work is essential for the welfare of the country, especially research. He said that by a resolution of the council the services of the society would be offered to the Government. In order to conserve our platinum resources he urged women not to use it in jewelry, and said it should not be used in photography.

ARTHUR J. BOYNTON presented a paper on "The Economic Resources of the Kansas City Zone." He said it was the natural center of the Southwest. He spoke of the railroads, bank clearance, agriculture, oil and gas, packing houses, soap and glycerin, flour and grist mills, cement, glass, brick, and metallurgical industries.

The Wednesday afternoon session was devoted to papers on Petroleum and Gas. H. P. CADY acted as chairman. WALTER F. RITTMAN's paper on "Synthetic Gasoline in 1918" was read by Gustav Egloff. He said we would produce one billion gallons of synthetic gasoline in 1918. Dr. Egloff, in an addendum to the paper, said we would save \$25,000,000 yearly in benzine, toluene and xylene if the gas standard was changed from an illuminating to a heat basis.

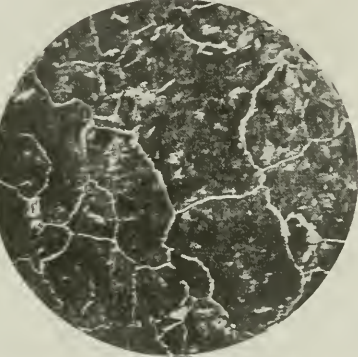
A full account of the whole meeting and of the technical sessions will be published in our next issue.



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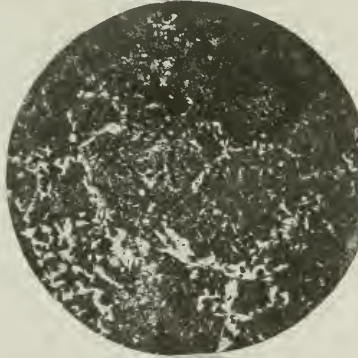
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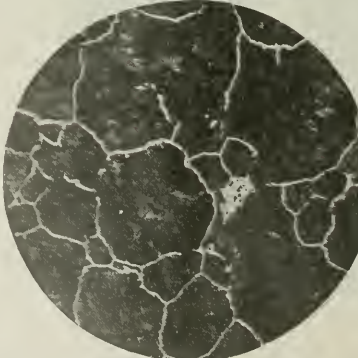
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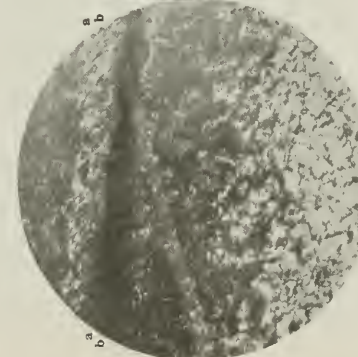
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MICROPHOTOGRAPHS OF STEELS "A" AFTER CEMENTATION

MICROPHOTOGRAPHS OF STEELS "A" AFTER CEMENTATION

Exfoliation and Carbon Concentration in the Case-Hardening of Steel*

By Edwin P. Stenger

Instructor in Metallurgy, University of Cincinnati

The demands being made on the cementation process by the different industries, especially the automobile and machine tool industries, can only be met by a better and a more detailed study of the principles and phenomena underlying this process. That great effort is being made to fill these demands is shown by the fact that so much attention and time is being given to research in this field of metallurgy by the most noted chemists and metallurgists.

Cementation of steel is defined as any process by which the carbon content of the whole or of a superficial layer of a steel object is increased without subjecting it to fusion. The object of the process is attained by heating iron or steel in contact with some carbonaceous material to a high temperature. The iron, in order to take up carbon from the carburizing material, must be heated to a sufficiently high temperature to be changed to the gamma condition.

If cementation is conducted so that only the carbon content of a superficial layer is increased, while the core is left unchanged, the process is called "case-hardening." If the treatment is continued for a longer time and at a higher temperature the whole of the mass becomes cemented. This method is termed "total cementation."

Although the best grades of crucible steel are still manufactured from iron that has been totally cemented, this method of making steel, originally the only one, has for economic reasons been almost entirely superseded by the Bessemer and open-hearth processes. Because other processes for steel making have been substituted, "total cementation" has become less important. On the other hand, superficial carburization is becoming more and more important, due to the recent advances in the technology of mechanical construction.

The most serious problem met with in the superficial cementation and hardening of machine parts is the phenomenon of exfoliation. This phenomenon is well known to all connected with the technique of case-hardening and to those who have occasion to examine the fracture of case-hardened pieces, after their failure in service. It very often happens that the cemented zones of a case-hardened object, especially if subjected to alternating shocks, as most cemented material is, splits or exfoliates from the core. This phenomenon has received the attention of Dr. Giolitti in his epoch-making work on cementation and to him is due credit for what little is known of this subject. He has investigated the distribution of carbon in the cemented zones obtained by carburizing with several of the hydrocarbon gases. This distribution of carbon in the cemented zone of case-hardened material has, as will be seen later, an important bearing on exfoliation.

It is evident that exfoliation is caused by some internal strain being produced during case-hardening. How these excessive strains could be produced by the case-hardening process has not been fully investigated.

During January and February, 1915, E. H. Schulz published in the "Zeitschrift des Vereins deutscher Ingenieure" a very important article on the changes in volume which steel undergoes during hardening. Several steels of different composition were heated by him to various temperatures and then quenched in oil and water. By finding the specific gravity before and after hardening, the increase in volume was determined. His results showed that the higher-carbon steels gave

greater increases in volume on hardening than did the low-carbon steels. Only a small increase in volume was obtained by quenching a steel whose carbon content was equal to .16 per cent. It should be noted that this is about the carbon content of most steel before it is subjected to superficial cementation.

With these fundamental facts as a basis, the writer undertook the present investigation. He thought that the greater increases in volume observed by Schulz in the hardening of the higher-carbon steels might be responsible for the phenomenon of exfoliation. It can be perceived that strains are produced in the case-hardening process if the higher-carbon case tends to increase in volume, while the low-carbon core tends to remain unchanged in size. The cemented zone will tend to expand from the unaltered core, thereby producing stress between the two which, if too great, will eventually result in rupture. In order to determine how great these stresses are, the following experiments were performed.

Carbon Concentration

The three types of steel most generally used for industrial cementation are ordinary low-carbon steel, nickel steel, and chrome steel. Materials of these types having the following composition were obtained:

Steel	C	Mn	Si	Ni	Cr	P	S
A.....	0.15	0.89	0.04	..	..	<0.05	<0.05
B.....	0.14	0.54	0.02	..	..	<0.05	<0.05
Ni.....	0.19	0.70	0.12	3.37	..	<0.05	<0.05
Cr.....	0.68	0.61	0.13	0.75	1.40	<0.05	<0.05

Steel B had been refined in an electric furnace. This steel was very kindly donated by the John A. Crowley Company of New York and was rolled by the Andrews Steel Company of Newport, Ky. Specimens of this steel were obtained for the experiments by shearing a No. 16 gage sheet of it into 1 1/4-in. squares. Specimens of the other three steels were obtained by cutting thin disks from a round bar. These disks were 1 1/2 in. in diameter and varied in thickness from 1/32 to 1/16 of an inch. A serial number was stamped on each piece in order that a record of its treatment might be kept.

These specimens were cemented in steel containers with a commercial carbonizing material called "Achilles." Each charge was made up of fresh carbonizing material in order that the composition would be the same in all cases.

The containers were made of two pipe sleeves joined together by a nipple having a diameter of 2 1/2 in. Both ends were closed with iron plugs. In one of these plugs a hole was drilled to permit the insertion of a thermo-couple, and also to serve to keep the gases under constant pressure, that is, atmospheric pressure.

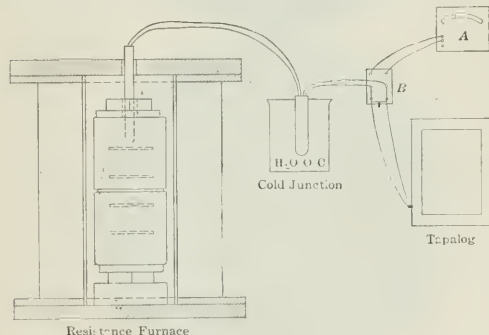
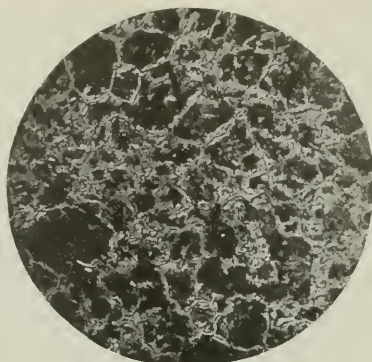
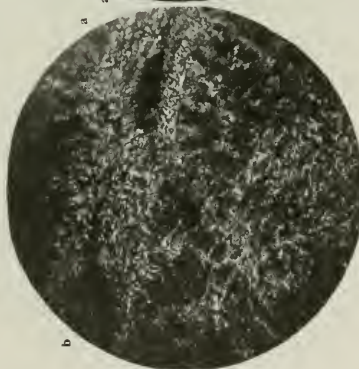
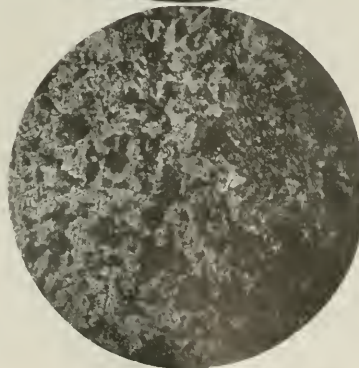
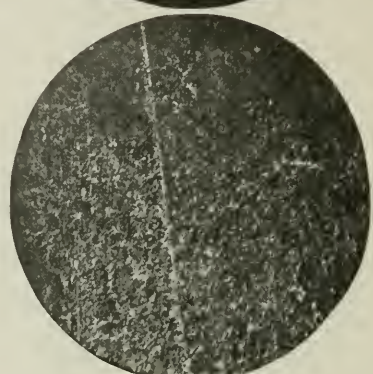
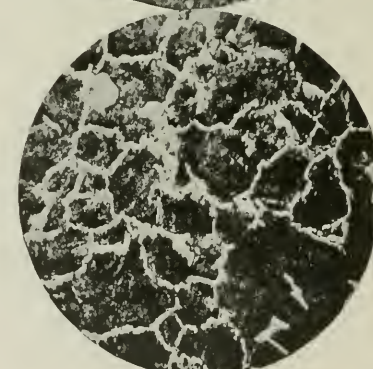
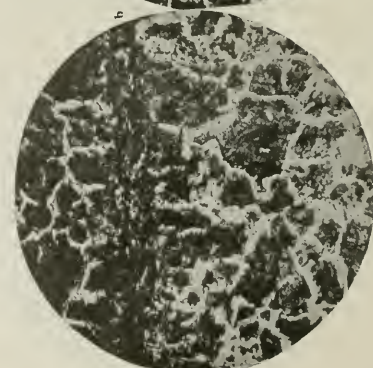


FIG. 1—ARRANGEMENT OF APPARATUS FOR CEMENTATION EXPERIMENTS

*Hochstetter Prize Thesis, University of Cincinnati 1916.

B₄ (910 Deg. C.)B₅ (800 Deg. C.)B₆ (740 Deg. C.)N₁₂ (845 Deg. C.)N₁₁ (790 Deg. C.)B₈ (1050 Deg. C.)B₉ (945 Deg. C.)

MICROPHOTOGRAPHS OF STEELS "B" AFTER CEMENTATION

MICROPHOTOGRAPHS OF STEELS "B" AND NICKEL STEELS AFTER CEMENTATION

The above description of the containers and the method of packing will be more clear if reference is made to Fig. 1, which shows the arrangement of the apparatus used for the cementation experiments.

The containers and their contents were heated in a wire-wound resistance furnace, to various temperatures. In these experiments it was endeavored to obtain the maximum concentration of carbon, corresponding to the saturation of iron, at a constant temperature. Therefore, the temperature was kept constant and the time of cementation was extended over as long a period of time as possible. In some instances, especially for the lower temperatures, the electric current could not be had long enough to cause the total cementation of the thin disks. The current was supplied by the University power plant which was in operation from only eight to fifteen hours each day.

One of the records of the temperature which were made by a tapalog recording pyrometer is reproduced

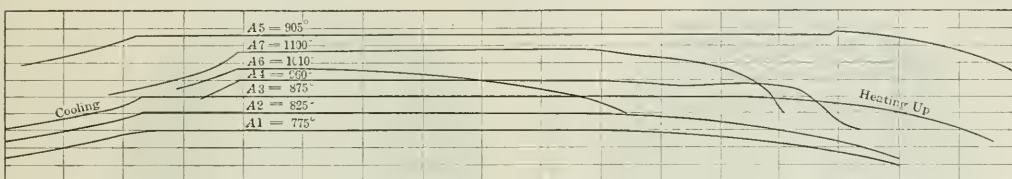


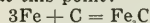
FIG. 2—TIME-TEMPERATURE CURVES FOR "A" STEEL

in Fig. 2. This instrument was not calibrated for the platinum-rhodium couple which was used, therefore the records serve only to show how nearly constant the temperature was kept and how long each charge was subjected to cementation. The real value of the temperature was obtained from observations made on the unipivot instrument A (Fig. 1) by throwing the double-pole double-throw switch B. The temperature record in Fig. 3 will be referred to below.

After cementation, microsections of the disks were made and examined in order to determine the structure

was not confined to either high or low temperatures nor to those disks which were saturated with carbon.

At first, one would conclude that since iron and carbon have been in contact at the surface and since iron carbide has resulted, that the following reaction must have taken place at this point:



The zones *a-a* would then represent the regions in which this iron-carbide or cementite is formed according to the above reaction. Cementation could then proceed by the diffusion of this cementite into the core, due to the

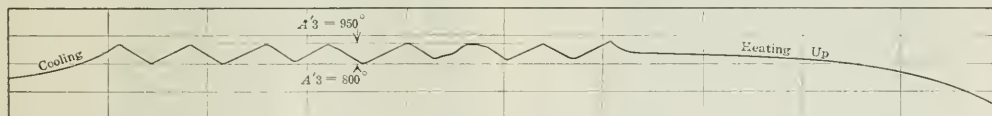


FIG. 3—TIME-TEMPERATURE CURVES FOR A'

and to see if the carbon was uniformly distributed throughout the entire section. The microsections were made by clamping together the four disks of each charge by means of a small bolt and then grinding and polishing a surface parallel to the axis of the bolt as shown in Fig. 4. If each disk had been polished separately, the edges would have been rounded, in which case the whole of the field could not have been brought into focus. For this reason they were clamped together, thus protecting six edges while only two were rounded.

To show the structure and the points of interest brought out in the microscopical examination microphotographs ($\times 125$ diameter) were made of the micro-sections and are reproduced on pages 424 and 426.

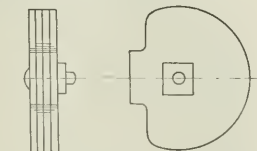
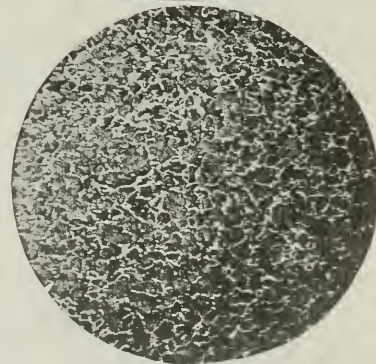
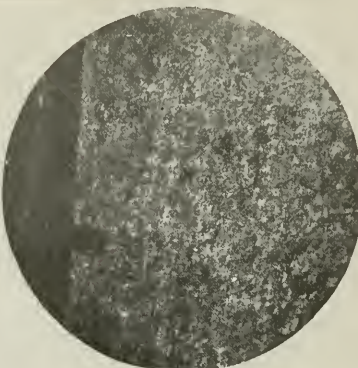
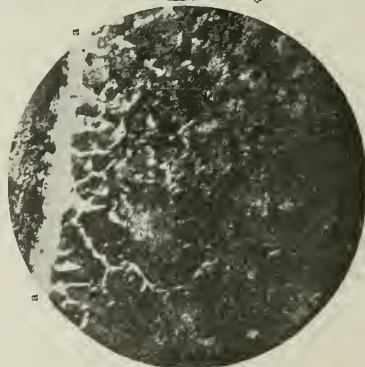
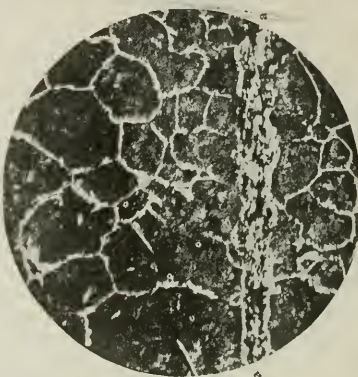
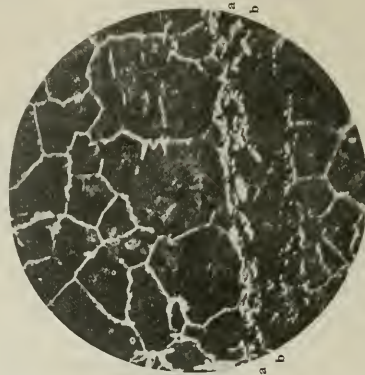
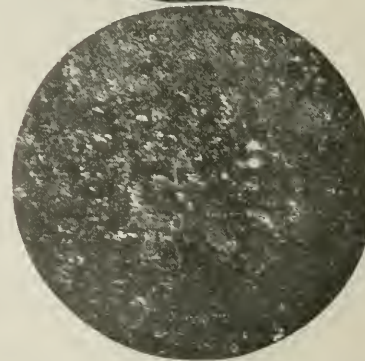


FIG. 4—METHOD OF MAKING MICROSECTIONS

difference in concentration. Although cementation may in part be due to the diffusion of the cementite from the surface to the core, this is not the preponderating agent of carburization, as will be shown.

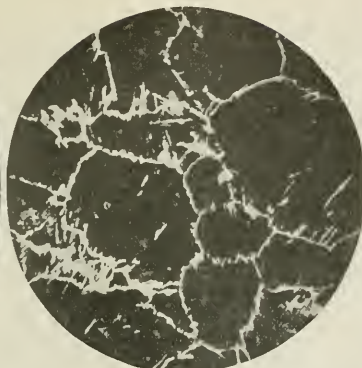
If formed in the manner described above these segregations of cementite would be found in all cases where the rate of formation of the carbide of iron would exceed the rate of diffusion. We would, therefore, expect to find these supersaturated zones in all of the micro-sections, since the rate of diffusion is zero when complete saturation is reached. Since these zones are found in only a few of the specimens, it is evident that they could not be formed in the above manner.

Giolitti found that no segregations of cementite appear when the temperature is kept rigorously constant, but that these supersaturated zones form only when there are oscillations in the temperature. In the microscopical examination it was found that supersaturated zones had formed in several of the specimens that had, according to the time-temperature curves, been subjected to the most constant and uniform temperature.

Ni₄ (1010 Deg. C.)Ni₆ (1140 Deg. C.)Cr₁ (730 Deg. C.)Cr₃ (850 Deg. C.)Cr₄ (890 Deg. C.)Cr₅ (940 Deg. C.)Cr₂ (800 Deg. C.)

MICROPHOTOGRAPHS OF NICKEL AND CHROME STEELS AFTER CEMENTATION

MICROPHOTOGRAPHS OF CHROME STEELS AFTER CEMENTATION

CR₁ (995 DEG. C.)CR₂ (1050 DEG. C.)

In order, therefore, to determine whether oscillations of temperature had any effect on the formation of these carbide segregations, the disks Nos. 20, 10, 11, and 16 of charge A₁ were again packed and subjected to cementation. This time the temperature instead of being kept constant was made to oscillate as is shown in Fig. 3. From the microphotographs A'₁ made after this treatment, we can conclude that Gjolitti's hypothesis was correct. A detailed explanation of the mechanism of the formation of these abnormal concentrations is given by him.*

It was observed in these experiments that the disks which were placed nearest to the top of the containers most frequently contained the segregations of cementite. In some cases the top disks contained considerable of the segregation while the other three were entirely free of it. The upper disk was not insulated as thoroughly as the other three were because it was covered with a much thinner layer of carbonizing material; therefore, its temperature oscillated more readily. This fact makes it doubtful whether much benefit will be derived from the work that is being done in search of a carbonizing material which is more permeable by heat.

Abnormal concentrations of cementite are formed in industrial cementation, especially if the furnaces used are fired intermittently as is the hand-fired coal furnace which gives a temperature curve somewhat similar to Fig. 3. These zones of cementite if formed in case-hardened parts will, when subjected to shock, flake from the surface in the form of thin plates. This flaking off of the supersaturated zones should not be confused with the phenomenon of exfoliation in which the entire case splits off. Although a rough surface may result from this cause, the problem is not serious because the zones are exceedingly thin. The cementite zone as it is shown in photograph A'₁ (the last microphotograph in the A series) is about 1/4 in. wide, which means that its actual thickness is about two-thousandths (0.002") of an inch. In practice these zones seldom exceed this thickness.

The segregations of cementite were removed from the disks by carefully grinding a thin layer of metal from the surface of each specimen. After this was done, drillings were taken from the disks of each charge and a determination of the carbon was made by direct combustion. These carbon determinations were made by Prof. E. E. Thum, for which assistance the author takes this opportunity to express sincere thanks. Likewise hearty thanks are due to Prof. James Aston under whose direction this work was started and to Prof. A.

L. Jenkins for his help on the mathematics connected with this investigation.

The value of the carbon thus obtained represents the maximum concentration of carbon corresponding to the saturation of iron at a constant temperature. Other investigators have attempted to determine these saturation points but their results, as they themselves have pointed out, are entirely too high because their analysis included the cementite segregations. They were unable to remove these segregations because fine wires were used for specimens. For this reason disks were used

for the specimens in the present experiments, which permitted the supersaturated zones to be ground off.

By plotting carbon against temperature, the temperature-concentration curves shown in Figs. 5 and 6 were obtained. If carbon were transmitted from the surface to the core by the diffusion of cementite only, these temperature-concentration curves would coincide with the

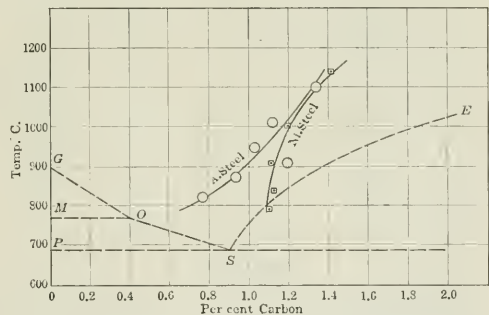


FIG. 5—TEMPERATURE CONCENTRATION CURVES

branch SE of the equilibrium curve of the iron-carbon system. These curves are greatly displaced from SE and are of a different shape. The fact that these curves do not coincide with SE confirms the recent theory that the carbon is transmitted by means of gases, rather than by diffusion of cementite, into the pores of the iron and on decomposition set up an equilibrium between carbon, carbon monoxide, carbon dioxide, and the solution of iron carbide in iron.

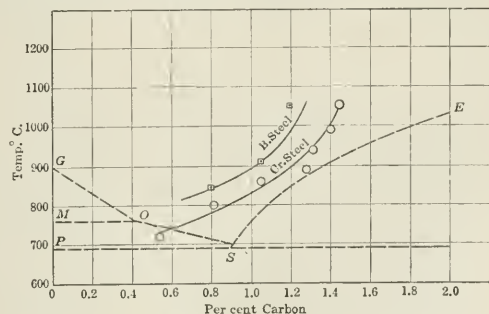


FIG. 6—TEMPERATURE CONCENTRATION CURVES

*See the "Cementation of Iron and Steel," by F. Gjolitti.

The temperature-concentration curves for A and B steel almost coincide, showing that small variations in the impurities always found in steel in the usual small amounts do not have a marked effect on the saturation point. On the other hand, the saturation curves are considerably lowered by high percentages of chromium and nickel. From the generally accepted theory that gamma iron is necessary to cementation, these curves should be tangent to the gamma iron transformation line on the iron-carbon diagram. The presence of nickel in steel has the known effect of materially displacing this transformation, which may account for the changed shape of the concentration curves.

The data for the preceding experiments are shown in tabular form in Table I.

Charge	Serial No.	Time, Hrs.	Temp. Deg. C.	Per Cent Carbon	Microscopic Examination	
					Interior Structure	Cementite Segregation
A ₁	14-19-22-31-34	7	775		Non-uniform	Little
A ₂	12-21-24-25	7	825	.77	Non-uniform	None
A ₃	20-10-11-16	10	875	.94	Uniform	None
A ₄	1-3-4-5	6	969	1.03	Uniform	Considerable
A ₅	26-30-46	12	905	1.20	Uniform	None
A ₆	18-17-32-33	1½	1010	1.12	Uniform	None
A ₇	8-15-23-27	6	1100	1.36	Uniform	None
A ₈	20-10-11-16	...	800-950	...	Uniform	Excessive
B ₁	104-15-30-33	11	740		Non-uniform	None
B ₂	102-08-17-29	10	800	.85	Rather uniform	Little
B ₃	105-24-25-32	11	850	.78	Non-uniform	Little
B ₄	119-10-23-31	9	910	1.05	Uniform	Little
B ₅	111-16-21-26	11	945	1.14	Uniform	None
B ₆	117-09-23-27	8	1050	1.20	Uniform	None
C ₁	202-17-21-19	9	790	1.10	Uniform	None
C ₂	223-25-11-10	9	845	1.13	Uniform	Considerable
C ₃	207-08-13-14	9	910	1.10	Uniform	Very little
C ₄	203-04-05-06	11	1010	1.19	Uniform	None
C ₅	241-01-20-16	5	1140	1.42	Uniform	None
C ₆	319-16-31-32	12	730	.54	Uniform	Considerable
C ₇	311-17-20-25	11	800	.81	Uniform	No. 332 only
C ₈	300-10-24-35	13	860	1.03	Uniform	Little
C ₉	305-15-23-30	12	890	1.28	Uniform	None
C ₁₀	307-12-21-32	10	940	1.31	Uniform	Little
C ₁₁	302-04-14-34	10	995	1.40	Uniform	Very little
C ₁₂	301-03-13	7	1050	1.45	Uniform	None

Exfoliation

Coming back to the problem of exfoliation, it was now endeavored to determine the increase in volume caused by the hardening of steel. Although, as has already been mentioned, Schultz made similar determinations his results have not been applied to practical problems and processes.

The case and the core of cemented parts differ in composition, so far as is known, only in the amount of carbon that they contain. This being the case the stresses due to volume changes in cemented parts must depend on this one element alone. The specimens of steel used by Schultz in his experiments were picked at random and contained all the elements usually found in steel in varying amounts. Then too, most of the steel

used by him had a much lower carbon content than that which cemented zones generally have.

On the other hand, the specimens prepared from the same material, as the disks in the above experiment were, differ only in carbon and the results obtained by determining the changes in volume on hardening these disks are therefore more applicable to cementation problems. Consequently, the disks, after the cementite segregations had been removed, were heated to 850 deg. C. and then rapidly cooled from that temperature by quenching in water.

The arrangement of the apparatus for this operation is shown in Fig. 7, which is self-explanatory. Two specimens of each steel which had not been cemented were also hardened in the above manner.

After hardening, the specific gravity of each of the specimens was determined and the results are shown in Table II, and in the form of curves in Fig. 8.

A most important and astonishing fact was revealed by the determination of the specific gravities of the nickel steel. From the data it can be seen that the specific gravity of the nickel steel after it is cemented and hardened is actually greater than that of the same material which is hardened but not cemented. Since

TABLE II
A. STEEL. QUENCHED FROM 850 DEGREES C.

Serial	W	W'	Specific Gravity*	Average Specific Gravity	Charge	Per Cent Carbon	I	Sr.
A ₁	25.0875	21.8978	7.866	7.868	A	.15	1.000	0
A ₂	26.5890	14.4752	7.869					
12.....	6.7762	5.0071	7.796	7.794	A ₂	.78	1.0065	88,000
25.....	9.7513	8.5001	7.793					
21.....	9.5418	8.3176	7.794					
1.....	14.8752	12.9636	7.777	7.777	A ₄	1.03	1.0078	105,000
4.....	13.3533	11.6364	7.777					
30.....	8.5790	7.4787	7.797	7.793	A ₅	1.20	1.0087	117,700
46.....	9.7356	8.4868	7.796					
41.....	12.0284	10.4831	7.784					
17.....	13.5431	11.8015	7.776	7.774	A ₆	1.16	1.0085	114,000
32.....	11.5563	10.0799	7.779					
33.....	14.2876	12.4480	7.766					
23.....	14.1166	12.3016	7.777	7.777	A ₇	1.36	1.0094	126,500
15.....	9.6962	8.4494	7.776					
8.....	13.6782	11.9194	7.777					

*Determinations made at 23 degrees C.

this is true, the core of this steel tends to expand more than the cemented zone, which is just the reverse of what happens when other steels are case-hardened. Therefore, tension and not compression is produced in the cemented zones of case-hardened nickel-steel parts. If this tension becomes too great, rupture will occur but

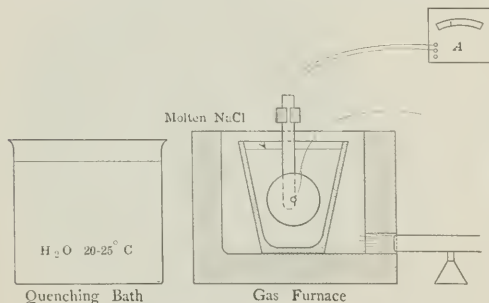


FIG. 7—ARRANGEMENT OF HEATING AND QUENCHING APPARATUS

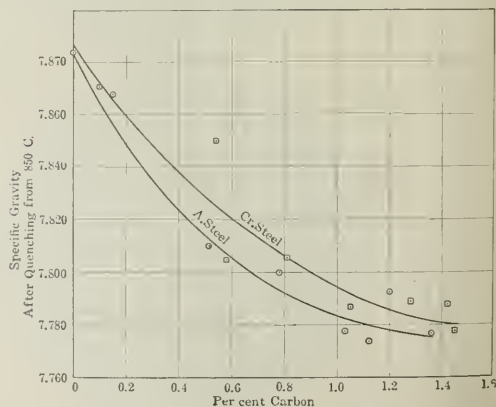


FIG. 8—DENSITY-CARBON CURVES

TABLE II (Continued)
B. STEEL. QUENCHED FROM 850 DEGREES C.

Serial	W	W'	Specific Gravity*	Average Specific Gravity	Charge	Per Cent Carbon	I	Sr.
B.....	9.4855	8.2836	7.892	7.896	B	.14	1	0
B.....	9.4358	8.2402	7.899					
117.....	8.3125	7.2489	7.816	7.814	B ₂	.84	Not calculated because the density was so affected by rolling that the specific gravity of the average carbon content could not be taken from curve	
129.....	9.1918	8.0160	7.817					
103.....	8.3248	7.2588	7.810					
132.....	8.2565	7.2270	7.818					
124.....	9.0322	7.8761	7.813	7.815	B ₂	.78		
105.....	9.0530	7.8946	7.815					
110.....	7.9871	6.9635	7.801	7.799	B ₄	1.05		
123.....	9.4678	8.2541	7.800					
131.....	8.4200	7.3400	7.797					
126.....	7.2735	6.3423	7.810	7.806	B ₄	1.14		
121.....	8.4503	7.3679	7.807					
116.....	8.3147	7.2490	7.801					
122.....	8.2818	7.0624	7.804	7.808	B ₄	1.2		
127.....	5.9100	5.1541	7.818					
107.....	7.3433	6.4023	7.804					

NICKEL STEEL. QUENCHED FROM 850 DEGREES C.

Serial	W	W'	Specific Gravity*	Average Specific Gravity	Charge	Per Cent Carbon	I	Sr.
Ni.....	18.0702	15.7742	7.870	7.868	Ni	.19	1	0
Ni.....	17.0084	14.8460	7.865					
221.....	3.8720	3.2972	7.944	7.931	Ni 1	1.11	1	Negative
217.....	3.7408	3.2694	7.938					
212.....	11.4110	9.9682	7.900					
211.....	13.1711	11.5018	7.898	7.911	Ni 2	1.13	1	Negative
210.....	11.2938	9.8653	7.905					
205.....	8.3384	7.2830	7.901					
207.....	13.6503	11.9201	7.889	7.898	Ni 3	1.10	1	Negative
208.....	8.3384	7.2830	7.900					
214.....	8.9293	7.8000	7.904					
203.....	13.5907	11.8667	7.883	7.891	Ni 4	1.19	1	Negative
205.....	17.0350	14.8779	7.892					
204.....	16.8756	14.7389	7.897					
241.....	10.9046	9.5244	7.901	7.880	Ni 5	1.42	1	Negative
220.....	18.4453	15.1033	7.876					
201.....	15.4646	13.4995	7.869					

CHROME STEEL. QUENCHED FROM 850 DEGREES C.

Serial	W	W'	Specific Gravity*	Average Specific Gravity	Charge	Per Cent Carbon	I	Sr.
Cr.....	16.8462	14.7069	7.870	7.870	Cr	.15	1	0
Cr.....	24.7193	21.5789	7.871					
319.....	4.0065	3.3966	7.857	7.850	Cr 1	.54	1.0034	41,400
326.....	3.3973	2.9656	7.869					
316.....	7.1102	6.2013	7.823					
325.....	6.6514	5.7995	7.808	7.806	Cr 2	.81	1.0065	89,700
317.....	4.9531	4.3196	7.818					
320.....	6.2789	5.4734	7.795					
310.....	11.3962	8.9308	7.777	7.787	Cr 3	1.05	1.0070	95,000
324.....	56.4725	5.6432	7.804					
300.....	11.1936	10.6266	7.781					
315.....	9.9382	8.6620	7.787	7.789	Cr 4	1.28	1.0091	122,800
323.....	6.6519	5.2769	7.802					
305.....	9.9020	8.6291	7.779					
333.....	7.5876	6.6147	7.790	7.781	Cr 5	1.31	1.0092	124,800
312.....	14.3212	12.4794	7.776					
321.....	9.1627	7.9834	7.770					
314.....	8.8145	7.6822	7.781	7.782	Cr 6	1.40	1.0096	128,900
302.....	14.7921	12.8890	7.773					
304.....	9.6173	8.3828	7.790					
301.....	15.6052	13.5977	7.773	7.775	Cr 7	1.45	1.0098	131,600
313.....	14.2587	12.4254	7.777					
303.....	12.6872	11.0576	7.778					

*Determinations made at 23 degrees C.

the resulting crack will be normal and not parallel to the surface as is the case in exfoliation.

These conclusions are confirmed by observations made by those engaged in the practice of cementation. During the writer's own experience he has never observed exfoliation to take place in case-hardened, nickel-steel

parts; the only trouble encountered in the cementation of this steel having been the cracks normal to the surface, which are occasionally produced.

Since the cylinder is the most common form used in case-hardened parts, an equation for the value of the stresses which tend to produce exfoliation in such a cemented form was derived by the application of the principles of mechanics. In this analysis of the stresses produced in a cylinder during case-hardening, the core was assumed to remain fixed in size. The cemented zone was considered to be a thin ring tending to expand away from the core but prevented from so doing by the internal stresses.

The following notations were used in the subsequent analysis:

D = mean diameter of the case before hardening in inches.

D' = mean diameter of the case after hardening in inches.

I = coefficient of total linear expansion due to hardening (not coefficient of thermal expansion).

S_h = unit hoop stress in pounds per square inch.

T = total hoop stress in pounds.

p = unit radial stress in pounds per square inch.

b = breadth of ring or length of cylinder

t = thickness of case in inches.

S_r = radial stress in pounds.

φ = Poisson's ratio of lateral contraction.

E = Young's modulus of elasticity for steel.

Fig. 9 shows the manner and direction in which the different forces act.

$$D' = DI.$$

The difference in the mean circumferential length before and after hardening equals:

$$(D' - D)$$

Unit elongation equals:

$$\frac{(D' - D)}{D} = \frac{D' - D}{D} \quad (1)$$

From Hook's Law, E equals unit stress divided by unit elongation. Therefore, since E remains about the same for all steel regardless of treatment and composition:

$$E = \frac{S_h D}{D' - D} \quad (2)$$

$$S_h = \frac{E (D' - D)}{D}$$

$$T = bt S_h = \frac{bt (D' - D) E}{D} \quad (3)$$

$$pDb = 2T \quad (4)$$

$$p = \frac{2T}{Db} = \frac{2Et (I - 1)}{D}$$

$$S_h = \frac{pD}{2t} = E (I - 1) \quad (5)$$

$$S_r = p + \varphi S_h \quad (6)$$

$$S_r = \frac{2Et (I - 1)}{D} + \frac{1}{4} (I - 1) E \quad (7)$$

Equation (7) gives the value of the stresses produced in hardening a cemented cylinder. The stresses occurring in other case-hardened parts, such as gears, pinions, cams, cups and the like, can be analyzed in a similar manner. From this equation it will be seen that the stresses not only depend on the volume changes due to differences in the composition of the core and the case but also on the thickness of the case and the diameter of the piece to be cemented.

The diameter D for a given machine part is fixed so that the only two factors by which the stresses can be

governed are the thickness of the case (t) and the coefficient of linear expansion (I) due to hardening.

The thickness of the case depends upon the time, temperature, pressure, etc., at which cementation takes place and can be controlled by governing these factors. A predetermined thickness of case can be obtained by consulting time-penetration curves that can be prepared for the various carbonizing materials.

As far as is known, besides the present investigation no work has as yet been done on the other factor

curves of the carburizing material that is used. Giolitti has determined these curves for some of the gaseous carbonizers but not much data is as yet available for the solid cements. For simplicity it was assumed that the carbon distribution curve for the cemented zone of the cylinder was a straight line, from which it follows that the average carbon content of this zone is equal to one-half the sum of the carbon contents of the surface layer and of the core.

The specific gravity of the average carbon content is found from the curves in Fig. 8. I is obtained by dividing the specific gravity of the core by the specific gravity which corresponds to the average of the cemented zone. By substituting this value of I together with the diameter D and the thickness t in equation (7) we find S_r . This method of computation is made more clear by the following example, in which the stress for a cylinder of A

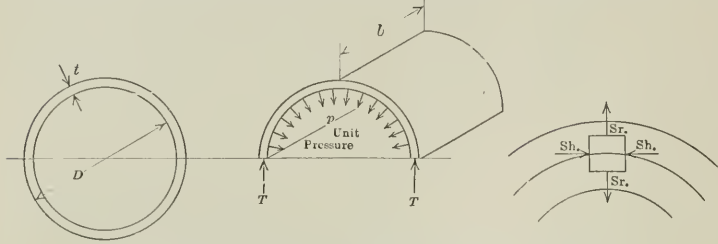


FIG. 9—FORCES ACTING IN CYLINDER DURING CASE HARDENING

of control I , the coefficient of total linear expansion due to hardening.

From the specific gravities determined above, it is seen that I depends on the amount of carbon that is present in the core and case. Equation (7) shows that small variations in I have a very marked effect on the stresses. To show how the stresses depend on the volume changes or indirectly on the carbon content the above data were used to calculate the stresses S_r produced by hardening a cemented cylinder 1 inch in diameter and having a case one-tenth of an inch in thickness.

The carbon is not uniformly distributed in the cemented zone but diminishes from the surface to the core. The mean average value of the carbon in the cemented zone must therefore be used in calculating the stresses and it is obtained from the carbon distribution

steel having a carbon concentration of 0.65 per cent at the surface was found.

Average concentration of carbon = $\frac{1}{2} (0.65 + 0.15)$ = 0.4 per cent.

Specific gravity from curve = 7.824.

$$I = \frac{7868}{7824} = 1.00562$$

$$t = 0.1 \text{ in.}$$

$$D = 1 \text{ in.}$$

$$S_r = \frac{2Et(I-1)}{B} + \frac{1}{4}(I-1)E = 75,900 \text{ lb. per sq. in.}$$

By similar computations the stresses for different concentrations of carbon in the low-carbon and chrome steel were calculated and the results are shown in the form of a curve in Fig. 10.

The carbon content of the chrome steel is higher than

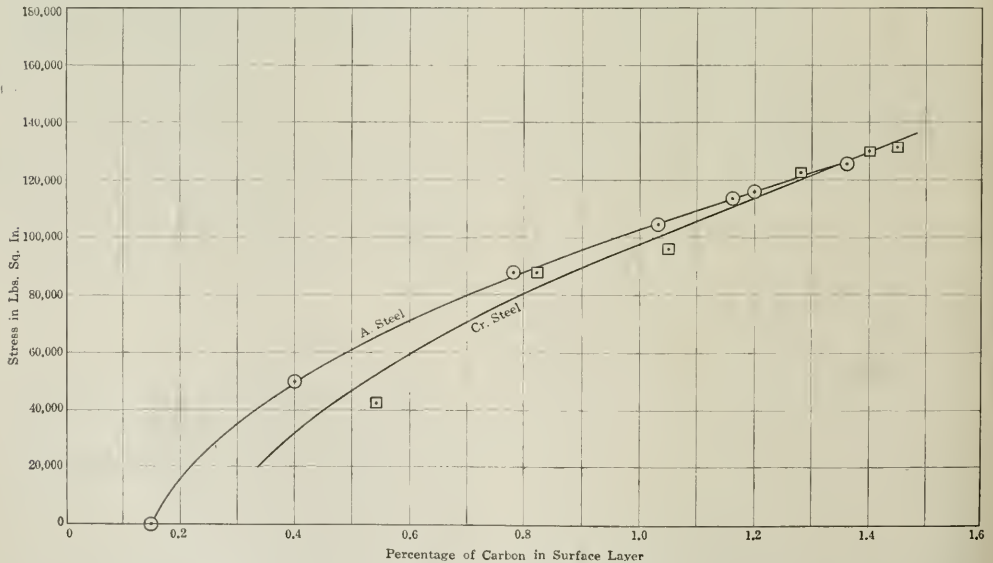


FIG. 10—STRESS-CONCENTRATION CURVES FOR A CASE-HARDENED CYLINDER; CASE 0.1 IN. THICK. DIAMETER 1 IN. QUENCHED AT 850 DEG. C.

what is generally found in material used for case-hardening purposes. Therefore, the specific gravity of the steel in the annealed condition was used for a basis in the calculations of the stresses. This value closely corresponds to the specific gravity of a low-carbon chrome steel after it has been hardened.

From the stress curves it is seen that very excessive strains are produced by the high-carbon cemented zones of both chrome and low-carbon steel.

The values of the stresses obtained by the above computations are higher than what actually occur in case-hardening because the rate of cooling during quenching, upon which the change in volume depends, is greater for the thin disks than it is for the larger machine parts. Lower values would also be obtained if the formula were refined so as to account for the increase in diameter of the core due to the deformation produced by the stresses. For the derivation of equation (7) this deformation was neglected, but more accurate results would have been obtained if it had been taken into account as was done by A. L. Jenkins in his analysis of the stresses produced in forced fits.* However, the difference in the rate of cooling and the refinement of the formula would not sufficiently reduce the value of the stresses to make thick cases and high concentration permissible.

Other stresses are also produced in hardening which may either act with or opposite to S . These stresses are produced by the thermal expansibility of steel. If a piece of steel is cooled rapidly, as by quenching, from a high temperature, the surface layer is cooled first and contracts upon the hot interior. In heating, the opposite is true. The exterior layer becomes heated first and expands before the temperature of the interior has been raised. During the quenching of most case-hardened parts, the contraction of the outer layer partly offsets the stress due to the higher specific gravity of the high carbon case. However, on reheating a case-hardened part the expansion of the outer layer increases S , by an amount which is dependent on the rate of heating and on the coefficient of thermal expansion. For this reason, the rate of reheating case-hardened parts which are subjected to the double heat treatment must be low.

The reverse, however, holds good for nickel steel. During quenching, the forces produced by the contraction of the outer case acts in conjunction with the stresses due to the difference in the composition of the core and case. On heating a piece of case-hardened nickel steel, the two forces tend to counteract each other. Thus, for this steel, the rate of heating after the first quenching need not be so low.

Since two forces act in the same direction when case-hardened nickel-steel parts are quenched it would seem that the rate of cooling must be kept low in order to prevent the tension cracks, which are normal to the surface. This does not hold to any great extent because the coefficient of thermal expansion of steel is considerably lowered by the presence of nickel. Then too, the stresses caused by the difference in composition of the core and the cemented zones of nickel steel are small, due to the small variations in their specific gravity.

Conclusion

From the results of this investigation it can be concluded that exfoliation is caused by the difference in the volume changes of the core and the cemented zone which take place during the hardening of cemented parts; also that since the stresses which tend to produce exfoliation can be subjected to a rational and logical analysis; they can be kept below the safe limit by designing the parts to be cemented, with a case having a

thickness and a carbon concentration compatible with the material used.

In the design of machine parts most elaborate formulae are used to take care of the external stresses while the internal stresses are allowed to take care of themselves. Manufacturers are aware of this fact, but this neglect cannot, as yet, be overcome because the internal stresses are not thoroughly understood and data regarding them are not available. Although the data obtained in this investigation are not applicable without modification to machine design, for reasons stated above, the method for obtaining these necessary data and the manner of applying them have certainly been pointed out.

The results of this investigation also account for other phenomena besides exfoliation. The evil effect of the segregation of carbon in steel is probably due to the same forces which produce exfoliation; the carbon itself being only indirectly the cause of the failures in such steel. Segregation is less noticed in nickel steel because the stresses produced by the volume change are low and therefore failure in this steel seldom occurs. It is not likely that nickel in reality prevents the carbon from segregating as is commonly believed, but it rather obliterates the harmful effect of such segregations.

The carbon-concentration curves are of theoretical interest, because they verify the present theory regarding the equilibrium established in the cementation process and show that the cementation action of the gases enormously preponderate above the direct action of carbon in the solid state.

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Electrical Porcelain*

By L. E. Barringer

President, American Ceramic Society

In joining this discussion concerning ceramic products I wish to first take advantage of such a gathering of chemists and engineers to explain the term "ceramics," as now understood by those immediately interested or engaged in ceramic engineering. Originally the term referred to strictly art wares such as might be found in museums or in Fifth Avenue shops, but during the past few years has been applied to the industrial and technical field concerned with the use or production of silicates. There are, of course, exceptions as in the making of magnesia brick in which no silicate is employed, or in the production of certain cements, but in general the ceramic industry may be defined as I have just indicated.

The three main classes of the ceramic industry are the clay, glass and cement industries and a smaller but very important branch is that of enameling metal wares for cooking, etc.

In the clay and cement industries use is made of silicates as raw materials.

In the glass and enamel industries silicates are produced from oxides, carbonates, feldspars, silica, etc.

There is no industry which can be more sharply or consistently defined than the ceramic industry and I am very anxious to see the term more generally and clearly understood among the engineering profession in general other than those immediately interested in ceramics.

CERAMIC INSULATION

In the electrical industry ceramic products (silicates), are employed extensively as insulating materials and I need only mention such substances as mica, slate, soap-

*An address made at the Feb. 9, 1917, meeting of the New York Section of the American Electrochemical Society, in joint session with the New York Section of the American Chemical Society and the Society of Chemical Industry.

*Engineering News, March 17, 1910.

stone, glass, porcelain and asbestos products to indicate immediately the extensive and varied use to which silicate or ceramic products are applied in the manufacture of electrical apparatus.

PORCELAIN FOR ELECTRICAL PURPOSES

This evening I am dealing with only one of these ceramic insulating products but probably the most important with the exception of mica, namely, electrical porcelain.

The art of making porcelain is practically as "old as the hills" and originated in China in very early times. The history of the development and progress of this highest of ceramic products is interwoven with the history of the world.

It was not until about 1852, however, that the use of porcelain was developed as electrical insulation. At that time attempts were being made to string telephone wires using gutta percha insulators. It was found that such material was not weather-resisting, however, and also that the sulphur mixed with the gutta percha rapidly corroded the copper wires. In experimenting it was found that adding clay to the mixture gave very much better results and that the more clay there was added the better the insulation. This logically led to using practically all clay and crude clay insulators were finally adopted. The gradual progress from such crude clay insulators to porcelain or the highest grade of clay insulator was natural and porcelain was finally employed for purposes of insulating overhead lines and any other places where a high-grade weather-resistant insulation was required.

Porcelain is preferable to and distinguished from other clay wares by possessing to a pre-eminent degree the properties of hardness, whiteness, high fusibility, translucency and density or impermeability.

Porcelain has a high dielectric strength and insulation resistance and a $\frac{1}{4}$ -in. thickness will usually not puncture under 70,000 volts and a $\frac{1}{2}$ -in. thickness under 100,000 volts. The increase of dielectric strength with thickness follows roughly a quadratic curve. As in all other insulating materials, both the dielectric strength and the insulation resistance fall with rise of temperature and at 300 deg. C. porcelain becomes a very poor insulator indeed. In fact, the dielectric strength begins to fall at 100 deg. C. and decreases very rapidly until the insulation is of a small order at 300 deg. C. The decrease of insulation resistance with rise of temperature is of the order 100 to 1 with rise of 51 deg. C.

The specific gravity of electrical porcelain is 2.4 and the coefficient of expansion 0.000004 per degree C. This coefficient of expansion is about one-third that of steel, one-quarter that of copper and one-fifth that of brass.

Porcelain is waterproof, weather-resistant, not attacked by oils, gases or vapors, shows no warping or shrinking with age, is readily formed or molded into the various intricate shapes required, is of comparatively low cost and has a pleasing appearance.

The crushing strength is high, averaging 20,000 lb. per square inch and the tensile strength ranges from 900 to 1800 per square inch.

From what I have said so far it might seem that porcelain was a splendid all-around insulating material and that there would be little or no necessity for the many other insulating materials which are employed in the electrical industry; but there are certain deficiencies in porcelain which prevent it from being the ideal insulation for all purposes.

In the first place, there is a lack of toughness in porcelain such as is required to withstand sudden shock or impact, or even the jar or vibration of certain pieces of apparatus. In using porcelain insulators on battle-

ships, for instance, it has been found that the gun fire will cause excessive breakage. The same is also true with reference to using porcelain insulators on electric locomotives or electric cars, where there is a considerable amount of jar or vibration. In electrical porcelain there is also little or no resistance to sudden heating or cooling and for this reason the material would not be suitable for use in controllers or rheostats or in other places where there is intermittent heating and cooling. It might be asked why electrical porcelain does not stand heating and cooling as well as chemical porcelain, but I would call your attention to the great difference in design. The thin and uniform walls of porcelain dishes used in the laboratory permit of their being heated through uniformly and quickly so that there is no great expansion differential. With the large irregular-shaped porcelains used in high-voltage insulation, however, any sudden heating causes local expansion and gives rise to cracking. The heat conductivity of porcelain is very low and a thick-walled piece will not heat through quickly.

There is also the drawback of non-flexibility and porcelain cannot be used for such purposes as insulating armature coils or other moving elements of electrical machinery where there is considerable bending and torsional strain.

Finally, metal parts cannot be imbedded or molded into place in porcelain as the high temperature used in burning will either melt the metals or else flux them with the silica of the porcelain mixture. In certain cases of insulation, therefore, the rigidity of construction cannot be secured with porcelain as with certain other molded materials.

The composition and method of manufacture of electrical porcelain is not unlike that of other porcelain wares, as ornamental porcelain, chemical porcelain, etc.

The materials employed in producing high-grade porcelain are kaolin, or china clay, ball clay, feldspar and silica.

The clays possess the valuable element of plasticity which permits of the ware being readily formed into the various shapes required. The clays have also the very valuable property of becoming indestructible upon firing. When clays are used alone, however, a porous mass or "body" is secured when the wares are fired unless the heat is carried to excessive temperatures which quickly melt or distort the pieces.

Feldspar is used as a flux to give a dense, vitrified body at a temperature readily attainable.

Flint is used as a stabilizer to extend the vitrifying range and to prevent the distortion of the pieces within a narrow temperature range as would result were feldspar and clay used alone.

All are familiar with the chemical changes which take place upon heating such a mixture as I have described. As the heat in the kiln increases the clay loses its combined water, this occurring within a temperature range of 600 to 900 deg. C. In the neighborhood of 1200 deg. C. the feldspar fuses and the clay begins to dissociate with the formation of sillimanite (Al_2O_3 , SiO_2). As the temperature still further increases the quartz is slowly attacked or dissolved by the feldspar up to 1400 deg. C., when solution is practically complete.

The final product consists of glass or fused feldspar in which is dissolved quartz and the silica resulting from the dissociation of the clay, sillimanite crystals and more or less of residual or undissolved quartz, depending upon the final temperature, or degree of vitrification.

Professor Binns* has already told of the general

*The paper by Professor Binns was published in our issue of April 1, 1917, page 395.

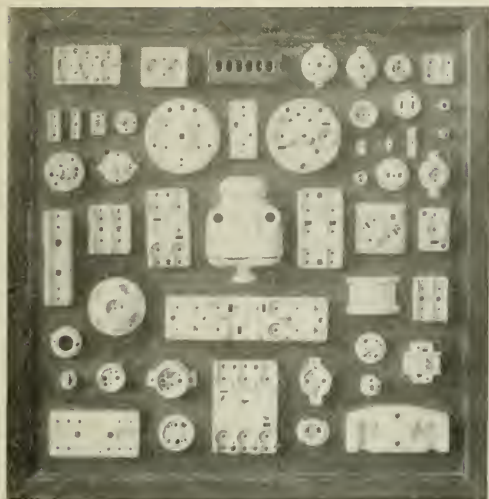


FIG. 1—DRY PROCESS PORCELAIN INSULATION

processes by which porcelain is manufactured and I will not repeat what he has said. For electrical porcelain the mixtures are prepared and handled practically along the same lines as has just been described by Professor Binns.

In the manufacture of electrical porcelain, however, the ware is classified into dry and wet processes, the former being that class of ware which is formed in steel dies and the latter that class of ware which is formed from the plastic porcelain mixture in the same manner as chemical or art porcelain. Figs. 1 and 2 illustrate both these classes of porcelain. The dry-process porcelain is used for low-voltage insulation and is seen in the form of cleats and knobs, etc., for the wiring of buildings for electric lighting. Wet-process porcelain is used for the making of insulators for high-voltage apparatus, as transformers, and high-tension switches and as insulators for high-voltage transmission lines. The wet-process porcelain is of considerably higher dielectric strength than the dry-process and is not absorbent. Wet-process porcelain will not absorb over $\frac{1}{4}$ of 1 per cent of water when immersed for forty-eight hours, whereas the dry-process may absorb as high as 1 per cent under the same conditions. The two classes of electrical porcelain are the same in composition but the difference in porosity and dielectric strength results from the different methods used in preparing the mixture.

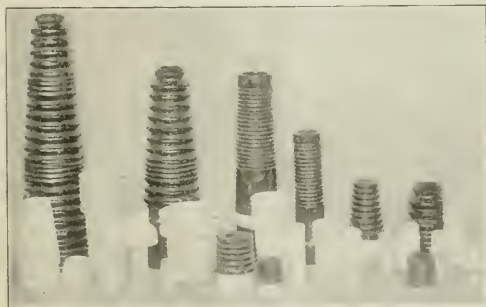


FIG. 2—WET-PROCESS PORCELAIN INSULATION



FIG. 3—CONTINUOUS KILN FROM DISCHARGE END

In the drying and burning of electrical porcelain there is no fundamental difference between the operations and the same operations in the handling of chemicals and art porcelains, and Professor Binns has already explained to you the general method of procedure.

I wish to call your particular attention, however, to an advanced type of kiln for firing porcelain. For many years the old bottle-shaped potter's kiln was used and all are no doubt familiar with this type of kiln. It produced the desired results but was extremely wasteful of heat. During the past few years types of continuous kilns have been devised and we are now operating a continuous kiln at Schenectady with very successful results and are saving about 50 per cent of the fuel required for operating the up-draft potter's kiln.

The kiln (Figs. 3 and 4) is a straight tunnel, 197 ft. long, with a fixed firing zone somewhat nearer the discharging end than the charging end. The ware is placed upon cars and moved through the firing zone to the cooling end. At the firing zone there are grates on either side. This combustion chamber is separated from the main tunnel by a narrow wall and the gases passed through tuyeres before entering the main tunnel. Air for combustion is preheated by passing through port holes at the discharge end. The air is heated by coming in contact with the outgoing cars of finished and cooling ware. Just before reaching the firing zone the flue is divided and part of the air (primary air), is deflected to beneath the grates to be used for combustion of the fuel. A second flue deflects a part of the preheated air (secondary air), into the main tunnel at the firing zone area where it serves for the combustion of incompletely consumed gases from the fire boxes. The gaseous products of combustion pass toward the receiving end of the kiln and serve to heat up the incoming cars of green or cold ware and then pass into



FIG. 4—SIDE VIEW, CONTINUOUS KILN

the main stack flue at the receiving end of the kiln. The stack temperature is only from 200 to 220 deg. C.

The temperature of burning is 1300 to 1400 deg. C. All ware is fired in saggars and a sand-seal protects the running gear of the cars from the burning gases.

Each car carries about 87 saggars 12 in. diameter of 6-in. high (inside). A kiln of the type under discussion is equivalent to about $3\frac{1}{2}$ of the ordinary potters' kilns of 14 ft. diameter. In addition to a saving in coal of about 50 per cent it has been found that the labor of handling or manipulating the kiln is slightly less and that the life of the saggars is increased.

This kiln represents a radical change and improvement in the method of firing, not only electrical porcelain, but ceramic wares of all kinds.

General Electric Co., Schenectady, N. Y.

Beet Molasses: Its Composition and Utilization*

By Sidney J. Osborn

General Chemist, Great Western Sugar Co.

Molasses is not only the most important by-product of beet sugar manufacture from a financial standpoint, but is also of particular interest chemically and from the point of view of the variety of ways in which it has been utilized.

In order to understand just what molasses is, let us consider the manner in which it is derived. Without going into any great detail regarding the manufacturing process, it might be said that the latter consists of two main operations, first the purification of the juice obtained from the beets, in which lime, carbon dioxide, and sulphur dioxide are the principal reagents used, and its concentration by multiple-effect evaporation to a syrupy condition, in which form it is commonly known as "thick juice." In the second part of the process this "thick juice" is subjected to fractional crystallization to obtain the sugar, that is as much of it as is possible to extract in this manner. It might be remarked that, in the process of crystallization in a sugar factory, peculiar difficulties are encountered in the high solubility of sugar and its tendency to form supersaturated solutions and in the great viscosity of the products which have to be handled. The methods of operation, which employ vacuum pans and crystallizers to produce the crystals, and centrifugal machines to separate them from the mother syrup, have been carried to a high degree of perfection under conditions which demand the handling of immense quantities of material with a minimum of trouble and expense, and are well worth the attention of those in other lines who have crystallization problems to solve.

As sugar is worth much more in the form of "granulated" than in the form of molasses we naturally try to crystallize out as much of it as possible, but there is an important limitation to the extent to which this can be carried. The impurities present in the juice, which are both organic and inorganic in character and are commonly for convenience designated as the "non-sugars," hold back a definite proportion of the sugar—in what way we shall examine later—so that it is impossible to carry the crystallization any farther when a certain ratio of sugar to non-sugar has been reached. This ratio, in the case of beet products, is that of about 60 parts of sugar to 40 parts of non-sugar. A reference to the analyses will make this clearer (Table I).

Molasses is then the final mother syrup obtained in the crystallization of sugar. It contains all the soluble impurities of the beet which have not been removed in the purification of the juice together with the sugar

associated with them. The importance of the molasses production will be realized when I say that of the sugar in the beet which enters the factory, 15 to 20 per cent passes out in the form of molasses.

The textbooks commonly distinguish between a "true" molasses and a "commercial" molasses. A true molasses is a mother syrup from which no more sugar can be crystallized out under the most favorable conditions of concentration and temperature. A commercial molasses is the molasses obtained in manufacturing operations in which the crystallization has been pushed to the limit that the apparatus and the time at disposal will permit, or the limit to which it is considered profitable to go. A commercial molasses is never a true molasses, but under efficient operating conditions approximates closely to it.

Theories of Molasses Formation

It has so far been mentioned that the non-sugar holds back or prevents a certain proportion of sugar from crystallizing, and this was the original theory of molasses formation, which was a mechanical one, viz., that the non-sugars exert a restraining power on the crystallization of the sugar, and that molasses is a super-saturated solution of sugar in water.

This theory, however, met with many objections, for, if the action of the non-sugar is merely inhibitive, it ought to be possible to push the crystallization almost indefinitely by suitable means, whereas we find that we reach very quickly a sharply defined limit beyond which crystallization will not take place. Let us consider also the following phenomenon. A saturated solution of sucrose, or pure sugar, at a definite temperature cannot dissolve any more sugar. If sodium chloride, however, or one of innumerable other salts, be added to the solution, not only will it dissolve but an additional amount of sucrose can also be dissolved in the same solution—in other words the solubility of sugar is greater in a salt solution than in water.

The study of such phenomena by many investigators resulted in the theories of beet and cane molasses formation which are now generally accepted. Herzfeld was led to the idea that beet molasses is a saturated solution of sugar in a non-sugar solution, or that it is a solution of sucrose-salt complexes, or compounds, which have a greater solubility than sugar alone. Greater details and definite proof of the existence of such compounds are lacking. However the hypothesis, as far as it goes, seems to meet most satisfactorily the conditions and phenomena which have been encountered.

The adjective "melassigenic," which as its derivation implies means "molasses forming," is frequently applied to the non-sugars. We have in discussing the theories of molasses formation spoken only of the melassigenic action of inorganic salts or non-sugars. It can hardly be denied that the organic non-sugars present in molasses have also a melassigenic action, although it has been demonstrated in various ways that the inorganic non-sugar is much more melassigenic than the organic non-sugar. This is a matter also of considerable commercial importance. It follows that, in order to obtain the maximum yield of crystallizable sugar, impurities or non-sugars of all kinds should be avoided or eliminated as far as possible, and in particular those of an inorganic nature, for every pound of non-sugar will carry with it into the molasses one and a half pounds of sugar which cannot be recovered directly as "granulated."

Commercial Importance of Molasses Formation

The question of the melassigenic action of the impurities is also of importance for determining a basis of settlement in transactions in commercial products such as raw sugar. The value of raw sugar depends

*A paper read before the Technik Club, Denver, Col., Feb. 13, 1917.

mainly, not on the percentage of sucrose which it contains, but on the amount of "granulated" which can be obtained from it. A hundred pounds of Cuban Centrifugal, for example, which contains 96 per cent sugar by the polariscope test, will yield about 90 pounds of granulated. Of the other six pounds, some is lost in the refining process, but the greater part of it goes into the refinery molasses.

In Germany, where most of the beet sugar is still manufactured in small factories in the form of raw sugar and sold to large refineries, the yield of crystallizable sugar, or "rendement," as it is called, which is used as a basis of settlement, is calculated by subtracting five times the percentage of ash from the polarization (the percentage of sugar indicated by the polariscope).

Melassigenic Action of Various Non-Sugars

To return to the discussion of the melassigenic action of inorganic salts, it should be stated that, while early experiments made with pure sugar and salt solutions showed that sugar is more soluble in certain salt solutions than in water, in solutions of other salts sugar is less soluble, or, to put it another way, the addition of certain salts to a saturated sugar solution will cause some of the sugar to crystallize out.

We accordingly had classifications of the common inorganic salts as melassigenic and non-melassigenic, or as positive, negative, and indifferent "molasses formers." If this is the case, it is exceedingly important for the sugar manufacturer to know what salts are harmful and should be avoided as far as possible, and what salts might actually be beneficial by their presence.

However it was soon shown that while a particular salt in a solution of definite concentration might be classed as a negative molasses former on the basis of such experiments as were described above, at a higher concentration it might have exactly the opposite effect, further its action might be entirely different in a solution of a mixture of several other salts.

It is therefore regarded at present as exceedingly doubtful if any salt is to be classed as a negative molasses former. It is rather regarded that all non-sugars contribute to molasses formation in varying degrees, and this is undoubtedly the safest view to take.

Composition of Molasses

Let us now glance at the composition of molasses as shown in Table I, where the percentages of the ingredients are given as commonly determined in sugar analysis. The first two analyses are taken from Browne's "Handbook of Sugar Analysis," and the third is an average of a great many samples of "discard" molasses of the Great Western Sugar Company. Just what is meant by "discard" molasses will be explained later.

Table I—Molasses Analyses.

	Typical Cane.	Typical Beet.	Great Western Sugar Co. Discard Beet.
Water	20	20	20.4
Sucrose	30	50	49.3
Raffinose	None	Present	2.9
Invert sugar	32	Trace	Trace
Ash	6	10	11.9
Organic non-sugar	12	20	15.5
	100	100	100.0
Ratio sugar to non-sugar	37½:62½	62½:37½	62:38
Ratio, sugar to ash	5:1	5:1	4:1
Saturated pure sugar solution at 20 deg. C. — 40 parts sugar to 20 parts water.			

With respect to beet molasses, the water which is determined by drying at 100-105 deg. C., amounts to about 20 per cent. The sucrose, which is determined with the polariscope, amounts to about 50 per cent. This is a figure worth remembering as it is the sugar content which gives molasses its chief value. This

sugar as we have previously seen, cannot be removed by direct crystallization, but is probably in the form of soluble sugar-salt complexes. Let us bear in mind, then, that beet molasses contains about half its weight of sugar.

A word about raffinose, also known as melitose or melitriose, which is likewise determined by polariscopic methods. Sucrose is represented by the formula $C_{12}H_{22}O_{11}$ and belongs to the class of disaccharides. Raffinose is also a carbohydrate and is a trisaccharide; its formula is $C_{18}H_{32}O_{16} + 5H_2O$. Raffinose is not a normal constituent of cane juice or cane molasses. It is, however, normally found in small amounts in the sugar beet, and becomes concentrated in the molasses. It should be stated, however, that the raffinose, as it is determined, is calculated simply from optical measurements made with the polariscope. It would be too long a digression to go into the matter fully here, but the consensus of opinion is that only a portion of what is reported as "raffinose" in Colorado molasses is actual raffinose, and that the remainder is an optically active, dextrorotatory gum, or a mixture of several such substances. The word "raffinose" is therefore to be regarded as the result of a certain determination rather than an actual percentage of a definite substance.

By the action of acids or certain enzymes, sucrose is hydrolyzed, or "inverted," as it is frequently called, and split up in the following manner. A molecule of sucrose ($C_{12}H_{22}O_{11}$) takes up a molecule of water and yields two molecules of simpler sugars, each having the formula $C_6H_{12}O_6$. These two sugars are isomeric; one of them is glucose or grape sugar, the chief constituent of corn syrup, or commercial glucose, the other is fructose, or fruit sugar. "Invert sugar" is simply a convenient expression for the mixture of equal parts of glucose and fructose produced by the inversion of sucrose. Invert sugar is not a normal constituent of beet juice or beet molasses and is not usually present in determinable quantities. It is on the other hand a normal constituent of the sugar cane and becomes concentrated in the molasses, where its amount is about equal to that of the sucrose present.

The ash, which is determined by ignition and is taken as a measure of the amount of inorganic non-sugars, amounts to about 10-13 per cent in beet molasses. The "organic non-sugar" is determined by difference and bears the balance of error made in the determination of the other constituents. The expression "organic non-sugar" covers a multitude of ignorance, especially as regards any quantitative data. It may, however, be said that the organic non-sugars of beet molasses consist largely of amino-acids or their derivatives and include such well known compounds as aspartic acid, glutaminic acid, and betain. There are no albuminoids present.

Cane Molasses

Little has so far been said about cane molasses, and to avoid attempting to cover too much ground it is not the object of this paper to deal extensively with it. There is one interesting relation between beet and cane molasses, however, which has been pointed out by Dr. C. A. Browne.

Recurring again to the theories of molasses formation, we see in Table I that the typical beet molasses contains 50 parts of sugar to 20 parts of water, where a saturated solution of pure sugar at ordinary temperature contains only about 40 parts of sugar to 20 parts of water. This greater solubility of sugar in beet molasses has been explained as due to the formation of sugar-salt complexes which have a greater solubility than sugar alone.

In cane molasses an apparently opposite condition ex-

ists. There is less sucrose than will saturate the amount of water present. We are indebted to Prinsen-Geerligs for a theory of cane molasses formation somewhat similar to that which has been given for beet molasses. Prinsen-Geerligs holds in brief that there exist in cane molasses compounds or complexes of salts and invert sugar, and that these complexes hold in combination a large amount of water of hydration which thus reduces the quantity of water available for solution of sucrose.

Table II.

Original Cane Molasses	After Fermentation of Invert Sugar	B with 8 Parts Water Evaporated	Percentage Composition of C.
A	B	C	D
Water	20	30	20
Sucrose	30	30	50
Invert sugar	32	0	10
Ash	6	6	10
Organic non-sugar	12	12	20
Totals	100	68	100

Now the idea has been held by some that if the invert sugar of cane molasses could be removed or destroyed in some manner, an additional yield of crystallizable sucrose could be obtained. There are some alcohol producing organisms which do not secrete invertase and which in pure cultures will attack invert sugar but not sucrose. Assuming that all the invert sugar could be removed in this way from the typical cane molasses in Table I, without alteration of the sucrose, what would result? After the removal of the invert sugar and evaporation to the previous concentration, as shown in successive steps in Table II, the percentage composition would be exactly the same as that of the typical beet molasses in Table I. In other words the molasses would simply be changed from a cane to a beet type, from either of which no sugar will crystallize. The idea therefore that, by destroying the invert sugar in cane molasses, additional crystallizable sugar could be obtained is plainly fallacious if the accepted theories of molasses formation are correct. Invert sugar is accordingly not a melassigenic impurity.

Utilization of Beet Molasses

Having discussed the composition of beet molasses and the theories of its formation, let us now pass to its utilization. As molasses, it will be remembered, contains sugar to the extent of half its weight, it is usually the sugar, and often the sugar alone, which is the valuable constituent in any method of utilization. It must not be forgotten, however, that the ash contains about 50 per cent potash (K_2O), and other valuable products have been obtained from the non-sugars. For convenience let us divide the methods of utilization into the following groups: Cattle feeding, alcohol production, extraction processes, miscellaneous.

Cattle Feeding

The impurities of the sugar cane have a pleasant, aromatic flavor, and raw cane sugar and cane syrups are common articles of human diet. It is different with the impurities of the sugar beet. While man demands his beet sugar in a purified form, it is fortunate for the general economy that the steer is not so particular. After the sugar is extracted from the beet, the residue the pulp, is used for cattle feeding, and after all the pure sugar that can be obtained from the juice is crystallized out another by-product results, the molasses, which finds wide application for the same purpose.

Molasses, in its original state, is not in a suitable condition for feeding on account of its sticky condition. Like almost any other single article of food, it is also not a balanced ration in itself. It does furnish a carbohydrate ration in a highly concentrated form, and as such is very valuable when used in proper amounts and

in suitable mixtures. The nature of the materials with which it is mixed will naturally depend on the locality in which it is used. In Germany, if we may believe what we read, peat seems to be used a great deal, not on account of its food value, but on account of its absorptive power, as well as bran and various kinds of meals. In our own section of the country alfalfa meal is, of course, the chief material used. Molasses is also frequently mixed with beet pulp.

While beet molasses contains as much as 8 per cent crude protein, by which is meant the total nitrogen multiplied by 6.25, this consists of water-soluble nitrogenous compounds about which there is some difference of opinion, but which it is probably safest to regard as not having an important food value. The food value really lies in the 50 per cent of sugar which the molasses contains. It also seems to be generally recognized that the salts in the molasses have a distinct value in stimulating the appetite and the digestion, so that larger amounts of forage are eaten. While objectionable effects may be produced if molasses is fed in excessive amounts, in quantities which by experience have been found suitable it is a very valuable addition to the animal diet.

Alcohol Production

A considerable amount of beet molasses, especially abroad, is used for the production of alcohol. It is hardly necessary to go extensively into this subject, as the process of producing alcohol from various raw materials is very much the same. It may be noted that, as the raw material in beet molasses is already present as a fermentable sugar, it does not require a preliminary malting as in the case of grain or potatoes, where the starch has first to be converted into glucose and maltose by the action of diastase.

The molasses is simply diluted to a suitable concentration, viz., about 17 to 22 per cent dry substance, and is then acidified with sulphuric acid. The acidification has a double purpose. Beet molasses is generally alkaline and yeast does not work well in alkaline solutions, further the presence of the acid prevents the invasion of bacteria and the setting up of false fermentations. The solution is next inoculated with yeast and allowed to stand at an initial temperature of about 65 deg. Fahr. (18 deg. C.). As the fermentation progresses the temperature gradually rises, and in the course of 48 or 96 hours, when fermentation is complete, the alcohol is distilled off in the usual manner.

The yield is always considerably short of the theoretical, on account of side fermentations and loss of alcohol by evaporation. With good practice a yield of about 3¾ gallons of 95 per cent alcohol per 100 lbs. of molasses, or about 75 gallons per ton, is said to be obtained. This is a little over 80 per cent of the theoretical and corresponds to the results of experiments in the laboratories of the Great Western Sugar Co.

As a corollary under this heading might be mentioned the use of molasses for the production of vinegar, in which the fermentation is carried a step farther to the acetic acid stage, so-called "generators" being used, consisting of large casks in which a dilute alcohol solution is allowed to trickle over beechwood shavings with free access of air.

Molasses Processes

Methods of utilizing beet molasses have so far been dealt with in which the molasses is used in its original condition, as in cattle feeding, or in which the sugar in the molasses is changed by fermentation into other products such as alcohol and vinegar. Processes will now be considered by which the molasses is treated so as to render possible an additional yield of crystalliz-

able sugar from the sugar in the molasses. In the light of what has been said about the nature of molasses, it is evident that such processes must consist either in removing some of the impurities so as to increase the ratio of sugar to non-sugar present, or in precipitating the sugar out in a purified form, so as to separate it from the bulk of the impurities with which it is associated in the molasses. It is also evident that all these processes depend for their return on the difference in the selling price of sugar in the form of "granulated" and of molasses. As "granulated" becomes cheaper and molasses more expensive, a point may eventually be reached where the margin of difference is not sufficient to offset the operating cost of such processes.

OSMOSE PROCESS

An historical review would not be complete without mention of the osmose process. This is one of the oldest of the molasses processes and has been operated down to very recent times, but to the author's knowledge it is nowhere in operation in the world to-day. For this reason it will be alluded to only briefly.

The osmose process is based on the familiar principle of osmosis, according to which the crystalloids tend to diffuse readily through a porous membrane while the colloids have a low rate of diffusibility. In practice the apparatus used, which is called an "osmogene," consists of a series of hollow frames arranged in a long row somewhat resembling a filter press in appearance. The frames are separated from each other by sheets of parchment paper. The hot dilute molasses is introduced at one end and circulates through every alternate frame. Hot water, introduced at the other end, circulates in the opposite direction through the intervening frames. There is thus a series of chambers containing alternately molasses and water.

Although sugar is a crystalloid, it has a lower rate of diffusion than the salts which are present in the molasses. While a considerable amount of the sugar in the molasses diffuses into the water and is lost, a more than correspondingly increased amount of the salts present is eliminated in the same way, so that the molasses issuing from the osmogene contains a higher ratio of sugar to non-sugar than it did before treatment. By reboiling this syrup in a vacuum pan and subjecting it to crystallization, an additional amount of sugar will crystallize out until the former ratio is restored, i. e., the ratio which represents the point at which no more sugar will crystallize.

The loss of sugar which passes into the osmose waste water is high. The yield is low—for a small amount of low-grade sugar and a large amount of molasses are obtained. This molasses can be "osmosed" a second time, but this results in a lower yield than is obtained the first time, and involves further loss of sugar and additional expense. The only thing to be said in favor of the osmose process is the cheapness of the installation. On account of the high losses and low yields it has been gradually superseded by other processes.

EXTRACTION PROCESSES

When it is desired to separate a substance from a miscellaneous collection of impurities, a common procedure is to precipitate it in an insoluble form with a suitable reagent. When the compounds of certain of the sugars are examined one is struck with the immense number of compounds which are formed by certain sugars such as glucose and fructose; these range from the additive compounds with hydrocyanic acid, for example, to the well-known hydrazones and osazones which Emil Fischer used to such advantage in his classic work on the constitution of the sugars. Sucrose,

however, forms very few such compounds; it does not unite with hydrocyanic acid, nor does it form a hydrazone or osazone. There is, however, a well-defined series of compounds of sucrose with the oxides or hydroxides of the alkaline earths. These are the sucrares, or saccharates, of barium, strontium, and calcium, and are made use of in the various extraction processes employed to obtain crystallizable sugar from beet molasses. In all these processes the saccharate is precipitated in an insoluble form and filtered out. It is then suspended in water, or in some cases added directly to the beet juice, and is treated with carbon dioxide gas. Carbon dioxide readily decomposes the saccharate, the sugar going into solution, and the insoluble carbonate of the alkaline earth metal being formed. The latter is then filtered out, and the filtrate contains the sugar which can be recovered by crystallization.

It is also interesting to note that nowhere in the beet sugar manufacturing processes proper is the sugar precipitated and separated in an insoluble form. The juice obtained from the beets is treated in various ways to precipitate and eliminate some of the impurities, and the sugar is then separated out by crystallization. In the extraction processes, however, the sugar is actually precipitated as an insoluble saccharate, which is filtered out and decomposed by carbon dioxide gas in order to recover the sugar. The extraction processes are therefore of considerable interest chemically, and have offered unusual problems both in chemical and mechanical lines.

BARIUM PROCESS

Barium forms an insoluble monosaccharate, represented by the formula $C_{12}H_{22}O_{11} \cdot BaO$. Baryta was the first chemical employed for the desugarization of molasses, and satisfactory results are said to have been obtained as early as 1849. The process has, however, never had an extensive application. It has been used in recent years in Italy, but is probably not being operated during the war. It is in operation at a factory in Canada, at Wallaceburg, Ontario. This is to the writer's knowledge the only factory in the world where the barium process is now in use. I had an opportunity to visit this factory two years ago, so can give some first-hand information.

The barium process as operated at Wallaceburg is as follows: A single vessel serves for both the precipitation and filtration, which operates by gravity. These iron vessels are about 4 or 5 feet in diameter and 3 feet deep. They are open at the top and have a screen of about 60 mesh near the bottom which serves as the filtering medium. There is an outlet pipe at the bottom, with a valve.

The proper amount of barium hydrate is first introduced in the form of a milk and is followed by the undiluted molasses. The contents are then mixed with a wooden paddle until within two or three minutes the precipitate of barium saccharate has formed and the mass has assumed a pasty consistency. The outlet valve is then opened and the mother liquor allowed to drain off. The precipitate is very granular and is readily retained by the screen. The first runnings, which are cloudy from the saccharate precipitated beneath the screen, are caught in buckets and returned to the filter. The precipitate is washed by pouring upon the filter first the sweet water from a previous filter, and then water containing a little barium hydrate. The cycle of operations requires an hour and a half.

After the washing the vessel is tilted and the barium saccharate is dumped into a mixer where it is mixed with water to form a milk. This is pumped to a carbonation tank, where it is decomposed with carbon

dioxide gas from the lime kiln. The liquid is then pumped through a filter press to remove the insoluble barium carbonate, and the filtrate, which contains the sugar, is mixed with the factory juice, which may be beet juice or cane liquor, accordingly as the factory is operating on beets or raw cane sugar.

So far the process is simplicity itself and the installation is extremely cheap. The difficulty and expense lies in the regeneration of the barium oxide. The barium carbonate cake from the filter presses has to be converted into barium oxide in order that it may be used again for the precipitation of sugar. This requires an extremely high temperature, and so far the only feasible process which has been found and the one which is at present used is to heat the cake to the necessary temperature in an electric furnace. The Wallaceburg furnaces are arc furnaces with carbon electrodes and are operated intermittently. The barium oxide is taken from the furnace as a red hot, sintered mass. It is allowed to cool, and broken up and slacked with water.

In simplicity of operation, in respect to losses and the purity of the saccharate obtained, the barium process proper leaves nothing to be desired. It is the electric furnace recovery plant which makes the barium process expensive both in cost of installation and of operation. If this part of the process could be essentially cheapened, it would be a tremendous step forward.

A further point should be mentioned. In the sugar business one is greatly limited in the choice of reagents in two important respects. In the first place, as sugar itself is such a cheap commodity, any reagent used must be inexpensive, or at any rate be capable of being recovered and used over again without too great expense. Secondly, as sugar and molasses are food products, it is necessary to avoid the use of substances of a poisonous or injurious nature which might contaminate the products. Barium salts are regarded as poisonous and if used there should be no doubt of their complete elimination. All sugar house juices contain soluble sulphates, and therefore any small amounts of barium which are not eliminated in the treatment with carbon dioxide ought to be completely precipitated as barium sulphate in the factory process. The claim of

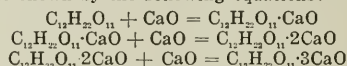
the Wallaceburg people that their sugar and molasses have always been absolutely free from barium, therefore, seems reasonable.

STRONTIA PROCESS.

Strontia forms both a monosaccharate ($C_{12}H_{22}O_{11} \cdot SrO + 5H_2O$) and a disaccharate ($C_{12}H_{22}O_{11} \cdot 2SrO$). The disaccharate, which is precipitated in a hot solution, is the compound made use of in the elaborate process by which a large proportion of the molasses production of Germany is desugarized. This is done at 5 large plants, each of which handles the molasses from a number of beet sugar factories'. Fig. 1 is a typical flow sheet of this process as used at the Dessau refinery in Germany. The illustration is self explanatory.

LIME PROCESSES

With calcium oxide, sugar forms three well-defined compounds, a mono-, di-, and tri-basic calcium saccharate, in which one molecule of sucrose is combined with one, two, and three molecules of calcium oxide respectively, as shown by the following equations:



The saccharates of lime are unstable compounds in that their constitution and solubility are so readily affected by changes in concentration and temperature.

If lime is added to a sugar solution in the proportion of one equivalent of CaO to one of sugar, the lime readily dissolves, forming the mono-saccharate, which is soluble in water but can be precipitated by the addition of alcohol. If, instead of adding alcohol, a solution of the mono-saccharate is heated to 80 deg. C., or close to the boiling point, the following reaction¹ takes place:



One-third of the sugar is precipitated as insoluble tri-calcium saccharate. On cooling, the saccharate redissolves. The reaction is therefore a reversible one, dependent on temperature. This reaction was used as the basis of a commercial molasses process at one time, but it has given way to the process which we are about to describe.

STEFFEN PROCESS

Now, if finely powdered quicklime is added to a sugar solution at a low temperature and in a mechanical device which is provided with means for keeping the solution cold and absorbing the heat developed by the reaction, also for distributing the lime slowly and as uniformly as possible into the solution while the latter is kept in rapid circulation—under these conditions the lime at first dissolves, forming the soluble mono-saccharate; in fact, up to this point the result is the same whether the lime is added in the form of caustic or slacked lime or without any of the special conditions which have been described.

Note these conditions particularly, for if simply an excess of lime be added to a sugar solution, only the mono-saccharate with an excess of calcium hydroxide is formed. If, however, the addition of finely powdered caustic lime is continued under the conditions described, the following result is obtained. The lime added continues at first also to dissolve, forming the di-saccharate which is soluble. Then when more lime has been added than is required for the formation of the di-saccharate, a white precipitate of tri-calcium saccharate begins to form, and by continuing the lime addition most of the sugar can be precipitated in this manner.

¹Taken from Stohmann-Schander, "Handbuch der Zuckerfabrikation."

²For simplicity water of crystallization has been omitted in the formulas of the saccharates of lime.

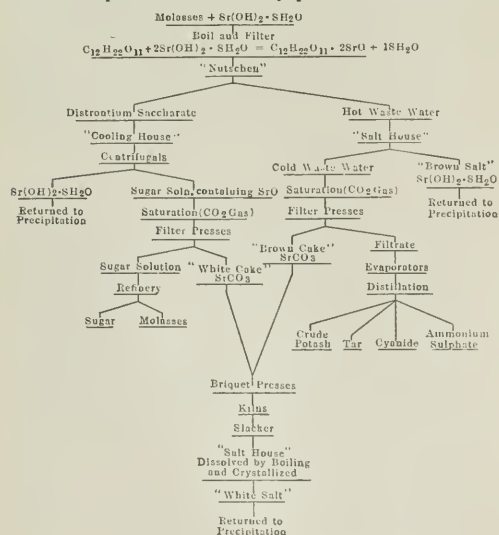
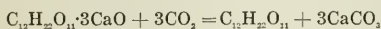


FIG. 1—STRONTIA PROCESS DESSAU REFINERY

It will be noted, therefore, that the insoluble tri-calcium saccharate can be formed in the cold as well as the hot. The cold process just described is known in Germany as the "Ausscheidungsverfahren," which translated literally means "separation process," but in this country it is always designated as the "Steffen process," after the man who developed it in a commercial way.

In practice the precipitation is made in a device known as a "cooler." This somewhat resembles a "standard" evaporator in appearance. It has a large central well, the space between the well and the sides of the cooler being filled up with several hundred vertical iron tubes between two tube sheets. A propeller at the bottom of the well draws the solution down through the well and forces it up through the tubes, thus maintaining a rapid circulation. The tubes are surrounded with cooling water circulated by a pump. The lime is conveyed to a hopper above, from which it is drawn into a box upon a platform scale, in order that the lime required for each cooler may be weighed accurately. It is then generally distributed into the cooler solution by means of a revolving bolter.

After the addition of the lime the liquid is pumped through a filter press, and the cake is washed with cold water. The filtrate, or "waste water," as it is called, goes to the sewer. The filter press cake, which contains the tri-saccharate, is diluted to the condition of a "milk" in a mixer, and the saccharate milk is then pumped to the main factory, where it is added directly to the beet juice. A factory which is not equipped with the Steffen process treats its raw juice with milk of lime and then with carbon dioxide gas. Where the Steffen process is installed, saccharate milk is simply substituted for milk of lime, and it is decomposed by carbon dioxide gas as has before been mentioned, insoluble calcium carbonate being formed and the sugar going into solution according to the equation:



The lime in the saccharate milk has the same purifying action on the juice as when milk of lime is used, and it carries with it the additional sugar which has been extracted from the molasses in the Steffen process.

FEATURES OF THE STEFFEN PROCESS

One essential feature for an economical operation of the Steffen process is a low lime addition. Theoretically only 49 parts of calcium oxide are required per 100 parts of sugar for the formation of calcium tri-saccharate. If an allowance be made for the lime dissolved in the mother liquor, which contains about 0.5 per cent sugar and has an alkalinity of about 0.75 per cent CaO, 100 parts of sugar ought to be precipitated with about 60 parts of calcium oxide. In a small laboratory cooler, using lime prepared in a laboratory furnace, no difficulty was encountered in precipitating over 90 per cent of the sugar with 65 to 70 parts of lime. A lime addition of below 100 is considered extremely good in practice, however, and is difficult to obtain.

When the Great Western Sugar Company first started work with the Steffen process, lime additions of 200 and more were not uncommon. The lime at that time was ground in large pebble mills such as are used in the cement industry and not over 60 per cent of the lime would pass a 200-mesh sieve. This meant that not only about half the lime was so much useless material, but, as the coarse lime developed so much heat when it slacked in the cooler, it raised the temperature of the solution and in this way seriously impaired the efficiency of the precipitation.

The introduction and perfection of a mill which pul-

verizes the lime and separates the finely ground particles by an air current marked a great step forward. It is now possible to obtain a large output of a product 98 or 99 per cent of which is finer than 200 mesh.

As one of the first essentials may be mentioned the use of limestone of high purity in order that the lime may have a high CaO content.

Reference also has been made to the fact that the lime must be in a caustic condition. This means that it must be well burnt, *i. e.*, free from carbonate, and it must contain as little hydrate as possible, *i. e.*, it should not be allowed to become air-slacked. In practice it is difficult to prepare lime which contains less than 1.5-2.0 per cent moisture. As one part of water is equivalent to 4.11 parts of calcium hydroxide, this means that 6 to 8 per cent of the lime, as we use it, is worthless on account of hydration.

It has also been said that the lime must be added slowly while the solution is kept in rapid circulation. Calcium oxide will combine with sugar in preference to water, but if at any point in the solution an excess of calcium oxide is present—this may be due to the presence of coarse lime or to an unequal distribution of fine lime—when all the available sugar has been used up the remainder of the calcium oxide will immediately slack, forming calcium hydroxide, in which condition it is useless for the precipitation of tri-saccharate. High lime addition may be caused by too slow circulation, by the presence of an excessive amount of foam which may accumulate on the surface of the solution and interfere with the lime distribution, and by imperfect bolters or lime distributors.

As regards temperature the lime addition is lower the closer the temperature of the solution is to 0 deg. C. Good results can, however, be obtained up to about 17 deg. C., and saccharate can be precipitated even above this, as shown in Fig. 2. In warm climates refrigerating machinery is almost essential for economical operation.

In Colorado, where there is an ample supply of cold river water during the greater part of the campaign, the installation of such machinery is hardly advisable.

As regards concentration, generally speaking the economy of lime is greater the more concentrated the solution is. Above a concentration of about 7 per cent sugar, however, the liquid becomes so heavy from the precipitated saccharate that a proper circulation cannot be maintained, and the lime addition apparently goes up for this reason. Colorado practice uses a cooler solution containing 5 to 7 per cent sugar. This means that the molasses must be previously diluted about 7 to 10 times.

As the precipitation of the tri-saccharate commences, the amount of sugar which is precipitated by a given unit of lime is at first small, it then rises to a maximum,

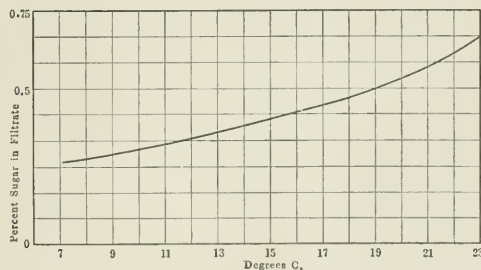


FIG. 2—PRECIPITATION OF SUGAR AT VARYING TEMPERATURE FROM A MOLASSES CONTAINING 5 PER CENT SUGAR

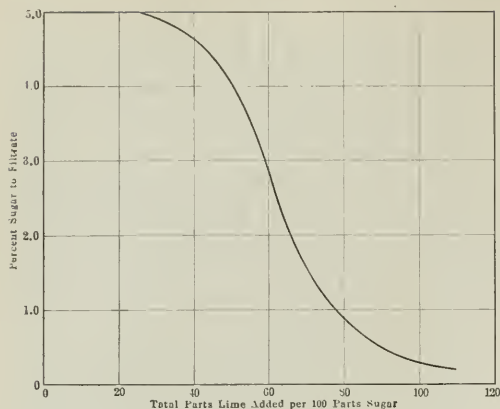


FIG. 3—PRECIPITATION OF SUGAR AT 5 DEG. C. WITH VARYING AMOUNTS OF LIME FROM A MOLASSES SOLUTION CONTAINING 5 PER CENT SUGAR

and from this point begins to decrease, so that, as the mother liquor becomes impoverished in sugar, more and more lime is required for the precipitation of a given amount of sugar. To reduce the sugar content of the mother liquor below about 0.4 per cent is difficult, even with a great excess of lime, and this is the point to which we generally aim to work in practice. If the original cooler solution contains, for example, 5 per cent sugar and the waste water, or filtrate, 0.4 per cent, it is evident that 93 per cent of the sugar originally present has been precipitated. See Fig. 3. For both curves the author is indebted to Messrs. Daniels and Roach.

FILTER PRESS WORK

The other essential for good Steffen work is the thorough washing of the filter press cake. This is much more difficult than with most cakes because the saccharate is to a considerable extent soluble in the washing medium, hence it tends to channel, and the filter press work is one part of the process that requires constant care and attention to obtain the best results.

"DISCARD" MOLASSES

It may be of interest to know how is determined what proportion of the molasses production shall be worked in the Steffen process and what proportion shall be sold for feeding. The Great Western Sugar Company aims to work all the molasses possible, but is limited in the following respect; there are some impurities which are very similar to calcium saccharate in their behavior, *i. e.*, they are precipitated by lime in the Steffen house and contaminate the saccharate cake. In the factory they redissolve in the carbonation and appear again in the final molasses. The continuous working in the Steffen process of the entire output of molasses therefore results in an accumulation of these impurities in the process. Further, these impurities are of such a nature that they render the massecuites extremely viscous and interfere seriously with crystallization. To eliminate them it is necessary to "discard" a portion of the molasses from time to time, and this is the so-called "discard" molasses, which is sold for cattle feeding. If it were not for the accumulation of these impurities, probably the entire production of molasses would be treated with the exception of the amount required for local feeding.

This so-called "discard" molasses is in no wise inferior

to ordinary beet molasses for cattle feeding. In fact, it is a little superior, as it contains more carbohydrates and less ash.

The Steffen process is operated at present to only a very limited extent abroad, but in this country it is used to desugarize a large part of the beet molasses. It is quite common for factories not provided with the Steffen process to ship their molasses in tank cars to other factories equipped with the process, providing the distance is not so great as to involve too high a freight rate. In fact, in order to avoid a large number of small units, installations are generally planned in this manner.

COMPARISON OF SACCHARATE PROCESSES

A brief comparison of the three saccharate processes may prove of interest. The cost of installation of the Steffen process is cheaper than that of either the barium or strontium processes, although the chief cost of the barium process lies in the electric furnace installation, and, if the regeneration of the barium oxide could be sufficiently cheapened, it might then have the lowest initial cost of the three.

The great advantage of the Steffen process lies in the fact that it is so well adapted for use in direct conjunction with a beet sugar factory. To explain what I mean, consider the barium process for example. After the precipitation of the barium saccharate the latter not only has to be decomposed in a special carbonation tank in order to recover the barium, but the factory has to use lime in addition to purify the juice. With the Steffen process the lime serves a dual role. It is used to extract sugar from the molasses in the form of saccharate and it serves later also for the purification of the beet juice.

The great disadvantage of the Steffen process is that it yields saccharate of the lowest purity, and consequently the smallest eventual yield of "granulated." For example, a sample of discard molasses yielded juices* of the following purity ("true" purity) after the formation of the saccharate and its decomposition with carbon dioxide gas: Barium saccharate, 93.05 per cent; strontium saccharate, 88.33 per cent; calcium saccharate, 81.22 per cent.

These purities are lower than would ordinarily be obtained because in the type of molasses used there is an accumulation of impurities to such an extent that it would be discarded and not again put through the Steffen process, but they are cited for the comparison. With fresh molasses, barium saccharate of 98 purity and calcium saccharate of 90 purity are not uncommon.

In spite of the much lower purity of the calcium saccharate, the writer is convinced the advantages of the Steffen process are such as to render it the most profitable for the ordinary beet sugar factory.

There are also some interesting contrasts that can be drawn. For example: in the commercial processes, barium is precipitated as the mono-saccharate, strontium as the di-saccharate, and calcium as the tri-saccharate. The strontium saccharate is precipitated hot, the barium at about 40 or 50 deg. C., and the calcium saccharate in the cold. In the barium process the molasses is used without dilution, in the Steffen process it is diluted with several times its weight of water, while in the strontium process the dilution is intermediate between the two. Finally, the strontium process is used by Germany, the barium process by Great Britain as exemplified in a Canadian factory, and the Steffen process by the United States.

SUGGESTED APPLICATION IN "FLOTATION"

There is just one afterthought. All of us have heard

*Daniels and Roach.

much of "flotation" and some of us are perhaps directly interested in it. In the flotation process the object is the production of a large amount of oily foam, and such substances as oils, acids and alkalies are said to be added to produce it.

In the Steffen process more or less foam is produced and much work is required to avoid it. This foam is extremely tenacious. The author has seen a Steffen house almost at a standstill from being filled up with foam, and if much is accumulated about the only thing to be done is to put men to work with shovels and wheelbarrows to haul it outside. The thought has occurred to the writer that beet molasses, to which a little lime has been added, might be an ideal foam producer for the flotation process, and it could be used in quite a dilute condition.

Recovery of Potash

In methods of utilizing beet molasses mention has been made only of the sugar. Among other valuable constituents is potash, which constitutes about 50 per cent of the ash (50 per cent KO). Potash has been recovered from beet molasses for a great many years, and in these days when muriate of potash has increased in price from \$40 to \$400 a ton the subject has, of course, excited considerable interest.

It is usually customary where potash is recovered to start with the waste water of one of the extraction processes, or the residues of a molasses distillery. In this way the sugar is first utilized and the potash is then obtained.

Potash is not being recovered to any extent in this manner in the United States, but, like many other industries for the lack of which American chemists have been soundly berated, there is no mystery about it. Starting with Steffen waste water, the first step necessary is to carbonate it to remove the lime which would otherwise scale up the evaporator, and then to concentrate it in a multiple-effect evaporator. It may be sold in this form to fertilizer manufacturers or it may then be burnt to an ash in a furnace with considerable reduction of bulk.

If sold as a concentrated liquor, the value will be based on both the ammonia (nitrogen) and potash content, while if it is ignited the nitrogen will be lost, but an ash can be obtained which contains 50 per cent KO, largely in the form of potassium carbonate. Market conditions will determine in which form it is better to produce it.

It is entirely a commercial proposition to calculate whether the cost of production, freight, etc., is sufficient to yield a fair return. In the case of the Great Western Sugar Company there is no close market for the product, and while almost any beet sugar factory could have paid for a potash recovery plant in one year with potash at war prices, there has been a natural hesitation to invest money in plants of this kind which might be ready for the scrap heap if the war should end at any time, as the installation costs run into fairly high figures.

It is possible that the company mentioned may yet do something in this line. At least three factories in North America are already utilizing their waste water in this way. Whether they will be able to continue to do so after the war in all cases is questionable.

Miscellaneous Processes

It is has been proposed at one time or another to obtain almost anything from beet molasses with the possible exception of radium. The author, however, has no desire to weary the reader with a recital of all these processes, real and imaginary. It might, however, be mentioned that beet molasses contains a considerable

quantity of betain, which is obtained from it commercially for medicinal purposes.

DESSAU PROCESS

In conclusion, mention should be made of the Dessau process, for it is characteristic of the thoroughness with which the Germans do things.

The Dessau process is operated, or at any rate has been recently operated, at two or three large plants in Germany, and employs for its raw material the waste water from the strontia process. This waste water is concentrated and subjected to distillation in a closed system. The gases, which among other things contain a considerable part of the nitrogen in the form of trimethylamine, are then passed through a "superheater" and heated to a high temperature, something like 1000 deg. C. As a result a rearrangement takes place which no one fully understands, and a considerable amount of hydrocyanic acid is formed. The gases also contain a large amount of the nitrogen in the form of ammonia. After removal of the tar the ammonia is then absorbed in sulphuric acid, the hydrocyanic acid in caustic soda, forming sodium cyanide, and the unabsorbed gases, which are combustible and have a high heating value, are used to supply heat for the process.

Very little has been published about this process. The writer has succeeded, in laboratory experiments, in obtaining one-fourth of the nitrogen as cyanide and one-fourth as ammonia. This corresponds with the yields as stated at that time, although it is possible that since then the efficiency has been improved.

To recapitulate, the products of the Dessau process are as follows: Crude potash (the residue in the stills), tar, ammonium sulphate, sodium cyanide and combustible gases, used in the process.

In these days when a serious shortage of cyanide is threatened in this country it may therefore interest some of the metallurgists to know that some of the cheap cyanide which they enjoyed before the war had its origin in a humble plant which is responsible for other things besides the sugar which it so abundantly produces.

Another Tin Smelter for the United States

About a year ago the American Smelting & Refining Company completed a tin smelting and refining plant at its Perth Amboy, N. J., works and has since been producing tin successfully from Bolivian and other foreign ores by a combination smelting and electrolytic refining process.

The National Lead Company concluded some important developments last year in the purchase of one-half of the capital stock of Williams, Harvey & Company, Limited, the largest tin smelters in Europe, having two plants in England, located at Liverpool and Hayle, Cornwall. The purchase contemplated the erection of a tin smelting plant in the United States, which will be operated in connection with the English company. An American company has been incorporated under the corporate name Williams Harvey Corporation to transact the business in the United States. The National Lead Company expends over \$10,000,000 a year in the purchase of tin which it markets in the form of solder, type metals, tin pipe, babbitt metals and other articles. The company has for many years smelted scrap tin and tin drosses. It has also experimented for several years with the smelting of tin ores in the belief that the tin ores of Bolivia, shipped through the Panama Canal, should logically be smelted in the United States for domestic consumption. A site of nine acres has been purchased on Mill Basin, Jamaica Bay, Long Island, and plans are under preparation for a large plant.

Some Studies on the Methods of Recovering Antimony from its Ores by Volatilization Processes*

By J. A. DeCew

Antimony sometimes occurs native associated with the metals, silver, iron and arsenic and in a number of minerals composed of these and other metals, but the chief ore is the sulphide stibnite (Sb_2S_3).

It may also occur in the form of oxide, either trioxide (Sb_2O_3) as valentinite or senarmonite, or the tetroxide (Sb_2O_4) as cervantite.

If the oxide ores are rich or can be concentrated, the metal can be recovered from them by fusion with reducing agents, but there is no profitable means of treating directly a low-grade oxide ore. The rich sulphide ores may be treated successfully by reduction processes, and are classified as smelting ores when they contain over 50 per cent of metal content.

These minerals of antimony are generally found in lenticular masses of varying thickness, carried in veins of either quartz or calcite.

As there are very few deposits of rich or high-grade ores in either Canada or the United States, any metallurgical process working on domestic ores must either follow a concentration treatment or must be adapted to the treatment of low-grade ores, at low cost and with reasonable efficiency.

VOLATILIZATION PROCESSES

Owing to the fact that the sulphide of antimony burns readily to the oxide Sb_2O_3 , and that both the sulphide and the trioxide are quite volatile, methods of treating these low-grade sulphide ores by combustion have been developed and used both in Europe and China. The mineralized oxides, however, as found in nature, are not sufficiently volatile to be treated by this process.

In the combustion process, the sulphur in the sulphide first burns to SO_2 , and then with rise in temperature the antimony Sb burns to Sb_2O_3 . These gases pass from the zone of combustion along with the excess air, and with reduction in temperature, the antimony oxide slowly leaves the gaseous form and becomes white fume. The completeness with which this oxide is transferred from the gaseous to the solid phase and the formation of solids having the right physical character are the essential elements of efficient recovery, although the problem of obtaining complete combustion of the ore is also very important.

COMBUSTION DIFFICULTIES

The burning of antimony sulphide is a simple reaction, but the accomplishment by ordinary means is quite difficult. For example, when the ore is burned in a stack furnace such as is shown in Fig. 1, it is not possible to maintain a uniform temperature in the charge. The bottom of the furnace will contain burned-out ore which is cooled by the draft of air supplied to the furnace. The central part of the zone of combustion will have the highest temperature, while the top part of the furnace will hold the freshly charged ore which will be but partially ignited and surrounded with gases poorer in oxygen. The conditions for satisfactory combustion exist, therefore, in only a limited part of the furnace.

Moreover, the properties of this mineral are peculiar. The sulphur ignites at a temperature near 200 deg. C. and the antimony at about 300 deg. C. The stibnite will melt at a temperature around 550 deg. C. and this is obviously much below the temperature resulting from

combustion. As a result a piece of rich ore would fuse and drop out of the zone of combustion before complete oxidation could take place. On the other hand, the sulphide begins to boil or vaporize at about 600 deg. C., so that unless the furnace is fed with a large excess of air, it is likely to distill over partially oxidized and thus become an impurity in the oxide.

There is another factor to consider and this is the fusibility of the associated vein matter and country rock. If the ore is associated with a decrepitating quartz, the rock containing the mineral will break up in the furnace and expose the mineral to oxidation, but if this quartz or associated rock fuses at the temperatures existing in the combustion zone, then the entire charge may fuse together, retarding combustion and blocking the furnace. On the other hand, if the vein matter consists mainly of a carbonate mineral such as calcite, then the difficulties resulting from fusion will be greatly reduced, but the gases of combustion will be greatly diluted by the liberation of carbonic acid. In any event a large oxygen excess is required, owing to the fact that the air will not pass uniformly through the ore mass and also because it is necessary to transfer the oxide gases quickly from the furnace to the condensing chambers.

OPERATING PRACTICE

In the shaft furnace shown about five volumes of air are used to one that is theoretically required, or about one-fifth of the oxygen in the air supply is actually combined with the sulphur and antimony and carbon in the ore. This is when an ore averaging about 10 per cent metallic content is used and when 4 per cent of coke is charged with the ore. The coke supply is required in order to maintain the combustion temperature in the furnace and extend its combustion area. The presence of this coke in contact with the ore, although it is a common practice, does not seem to have a proper theoretical basis, for it is only partially consumed during the time required for the ore to pass through the combustion zone, and it increases the possibility of local over-heating when combustion conditions are favorable. If this fuel were used to heat the air supply to about the ignition temperature of the ores, one would reasonably expect to have more uniform furnace conditions than that obtained in the ordinary furnace.

ROASTING FURNACES

The process of recovery of antimony by the production of the volatile oxide was developed in France by several inventors. One inventor named Hering used a reverberatory furnace for roasting, while another, Plews, used a revolving furnace heated with an oil or gas blast, which could be regulated to produce alternately an oxidizing or reducing flame. The only type known to have been used in Canada is the Herrenscheidt or stack furnace, although it would seem that a properly designed revolving furnace would be well adapted to the roasting of these ores, because in such a type the combustion of the extra fuel required takes place externally and there should be more complete combustion with less trouble from ore fusion.

If the stack furnace is properly designed, so that the temperature in the central portion of the ore does not produce caking from fusion, and if the depth of the combustion zone be so regulated that the antimony in the ore is completely volatilized and burned, then its efficiency would be quite equal to any other type and it would be of simple construction. In order to obtain these results, the furnace should be relatively deep and not too large in diameter. The area should increase with the depth so that even in case of fusion the ore would not be held up by the side walls. When ores does

*A paper read before the Canadian Society of Civil Engineers on March 15, 1917.

cake in a furnace it must be broken down by rods inserted from the top of the furnace, and this not only results in loss of oxide, but is dangerous to the men.

CONDENSATION OF OXIDE PRODUCED

After the antimony sulphide is converted to antimony trioxide (Sb_2O_3) and sulphurous acid (SO_2), the problems of condensation and recovery of the oxide are the chief consideration. To accomplish this completely and efficiently is exceedingly difficult, owing to the fact that the conversion of the oxide from the gaseous to the solid state takes place more slowly as the oxide condenses because of the reduction in the vapor pressure of the oxide. The boiling point of Sb_2O_3 is 1550 deg. C., but it is molten at red heat, so that any oxide which separates from the vapor form at temperatures above 750 deg. C. will appear as liquid particles and will build up upon the condensing surfaces in very hard and dense masses called coral oxide. Such material is very hard to grind and it cannot be marketed in this form as oxide,

nor can it be converted to metal as efficiently as can the snow-like deposits formed at lower temperatures. When the oxide is changing from the gaseous to the solid phase at temperatures below the point of fusion, it first forms a fog or fume, in the same way that a solid will separate from aqueous solution forming minute ultra-microscopic or colloidal particles. These exhibit the Brownian movement, which is the rapid vibration of individual particles, observed in all colloidal dispersions. These minute solids although in a gaseous medium will exert an osmotic pressure, similar to that of colloidal particles in an aqueous medium. This osmotic pressure resists the effect of gravity, and a state of equilibrium will be established between the two forces, which will have a selective influence upon the particles. The Brownian movement will cease and the osmotic pressure become negligible when the particle grows to a diameter of 10 microns, which is just about the visibility of the naked eye. Any particles larger than this would be acted on only by gravity and will settle in a reasonable

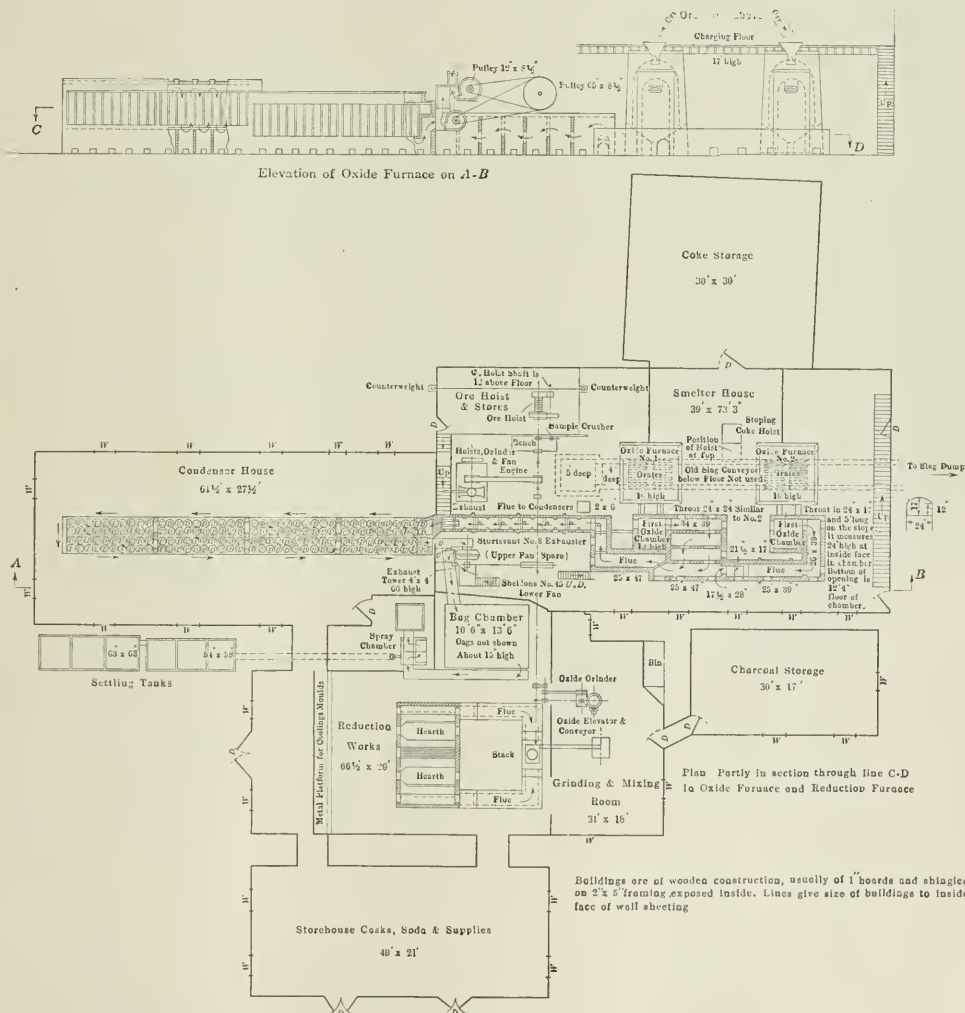


FIG. 1—ELEVATION OF STACK FURNACE AND PLAN OF COMPLETE PLANT

time. Among all of these particles there is a strong electro-repulsion, owing to the fact that they carry similar electric charges. Each particle is surrounded with a layer of air or gas, which also seems effected by the electric charge, and when these particles finally do settle upon each other, they do not actually come into contact, but are held apart by a film of gas. While in this condition they roll upon each other with great facility, and the density of the oxide is very low.

Considerable mechanical pressure and agitation is required to increase the density of such an oxide to any appreciable extent. When a substance is in an aqueous colloidal solution, which is the liquid solid phase, electrolytes have the property of discharging the electrical properties of these colloidal particles, but there is no such ready means of destroying the electrical properties of particles formed in the cooling of a dry gas. The rate at which the gas is cooled, however, has an influence upon the size of these particles. When the gas solidifies slowly there is a high degree of dispersion of the fume resulting in the formation of fine oxide, but when the entire antimony vapor is quickly solidified a denser oxide must be formed, because the dispersion means being constant the concentration must be greater. The condensation of the oxide may take place over a wide range of temperature, the amount remaining as gas at any given time being a function of the temperature and the vapor pressure. In order therefore to obtain a good recovery of oxide, it is necessary to bring the gases to a low temperature in the shortest possible time. This is difficult because a dry gas is a poor conductor of heat, so that considerable surface contact will be required to obtain a quick and uniform cooling. These gases, of course, are always dry as long as the temperature is over 100 deg. C. even if water vapor is present.

In order to recover the solid oxide by means of sedimentation or dust collecting devices, the original velocity of the gases must be very greatly reduced. As the volume of air passing through the ordinary furnace is about five times that which is theoretically required, and this volume is considerably increased by being raised to higher temperatures, and being also augmented by any air leaks in the condensing system, a very large condensing area is required in order to reduce the velocity of the gases to the point that will allow the finely divided particles of oxide to settle by gravity. Otherwise they will be carried entirely through the ordinary system regardless of its length, being held in suspension partly by air currents and partly by osmotic pressure. Mixing the gases with water vapor and then rapidly cooling them to a temperature at which the water will be condensed might have the effect of reducing the tendency of the condensed oxide particles to repel each other so that they could pack together in a mass, but under ordinary dry cooling conditions each particle of dust seems to have an electrical charge which repels all other particles whether liquid or solid. If, therefore, an endeavor be made to separate these gas-suspended particles by passing the gases through a scrubber containing water sprays, it will be found that a portion of the solid particles will be knocked down mechanically by the weight of the liquid particles, but owing to the surface tension of these liquid particles, the solids do not become wet for some time. There is in fact a repulsion rather than an affinity between the two substances, and as a result the efficiency of this type of scrubber is in such a case much lower than one would anticipate. The use of a water scrubber in the recovery of antimony oxide is only to be recommended for the treatment of those gases which have not yielded up their suspended solids by other means. The reason for this is that the oxide is not marketable in the wet state and it is a very difficult

product to dry. After it is dried it will be in the form of hard cake that must be finely ground before it can be reduced to metal in the reverberatory furnace.

The limitation of the efficiency of dry condensing systems is apparent when it is remembered that from the combustion of antimony ores the total volume of gas is very large, representing about 50,000 cu. ft. of gas to 1 ton of ore containing 10 per cent antimony (Sb), and also when it is remembered that the velocity of the falling particles is proportional to the square of their radii. It has been found that this law applies even to microscopic particles as small as $1/10$ of a micron and even for molecules no larger than $1/1000$ micron. The falling velocity under the influence of gravity of all particles under 10 microns in diameter, will be very slow, and if the oxides exist in this degree of fineness other means than ordinary sedimentation must be devised.

Methods have been recently used in the separation of such very fine particles from a liquid medium by means of the application of centrifugal force. By the use of a very rapidly moving rotor, it was found that a force could be developed equal to 40,000 times that of gravity. By such a force ultra-microscopic particles can be separated from a liquid medium, and if a centrifugal machine were devised for the separation of solids from a gaseous medium, which could handle a considerable volume of gas, the problem of collecting antimony oxide fumes would be a comparatively simple one. This principle is mentioned as one having possibilities in connection with future developments, rather than one for immediate application.

There is already established a very successful process for the collecting of all solid or liquid particles existing in the finely dispersed condition of fume or smoke. This system is known as the "Cottrell process," and is an exploitation of the electric properties of the individual particles above described, so that by means of electric charges passing through the gaseous medium, the particles are all gathered together at one of the poles. The process is very simply carried out by suspending a series of wires in a series of pipes and through these the gases carrying the solids are allowed to pass. High voltage electric currents are then passed from the wires to the pipes, and as a result all the particles suspended in the gases are attracted to the sides of the pipes and held there. These collections are loosened by mechanical agitation applied from time to time and the product drops from the pipes into containers below. (Fig. 2 shows such a condenser which has recently been designed for antimony fumes.) This process is now rapidly replacing all inefficient types of sedimenting systems, and is also recovering many products which have heretofore been entirely unobtainable by other means. As applied to the recovery of antimony oxides, it is probable that the high velocity with which these particles would be withdrawn from the gaseous medium from which they are condensed would pack them together on the sides of the pipes in a more dense mass than would be possible by any gravity separation. For a given density the state of subdivision in the electrically recovered product would be much greater than in that from the gravity separation, for in the latter the higher density would only be obtained by an accumulation of heavy particles.

DESIRABLE PROPERTIES OF THE TRIOXIDE

The trioxide is in demand for ceramic work owing to its fusibility and its property of producing a white opaque glass. One of its large uses is in the manufacture of white enamel ware, and for this purpose it is first blended while dry with other substances. Although

color, purity and fineness are important properties, yet the specific gravity is also a factor because the oxide may be so light that it is difficult to work with it. There are always ways of increasing the density of a product such as this by mechanical means, but if it could be recovered in such a manner that it would be both fine and dense, such a process would be much superior. Electrical precipitation seems to promise the best results in this connection.

When antimony sulphide is heated to a temperature above 350 deg. C. it burns to antimony trioxide and sulphur dioxide. The antimony trioxide is fusible and volatilizes at temperatures above 700 deg. C. If the trioxide is heated to high temperatures in presence of air the tetroxide is formed. The tetroxide is non-fusible and non-volatile and insoluble in mineral acids with the exception of concentrated hydrochloric acid.

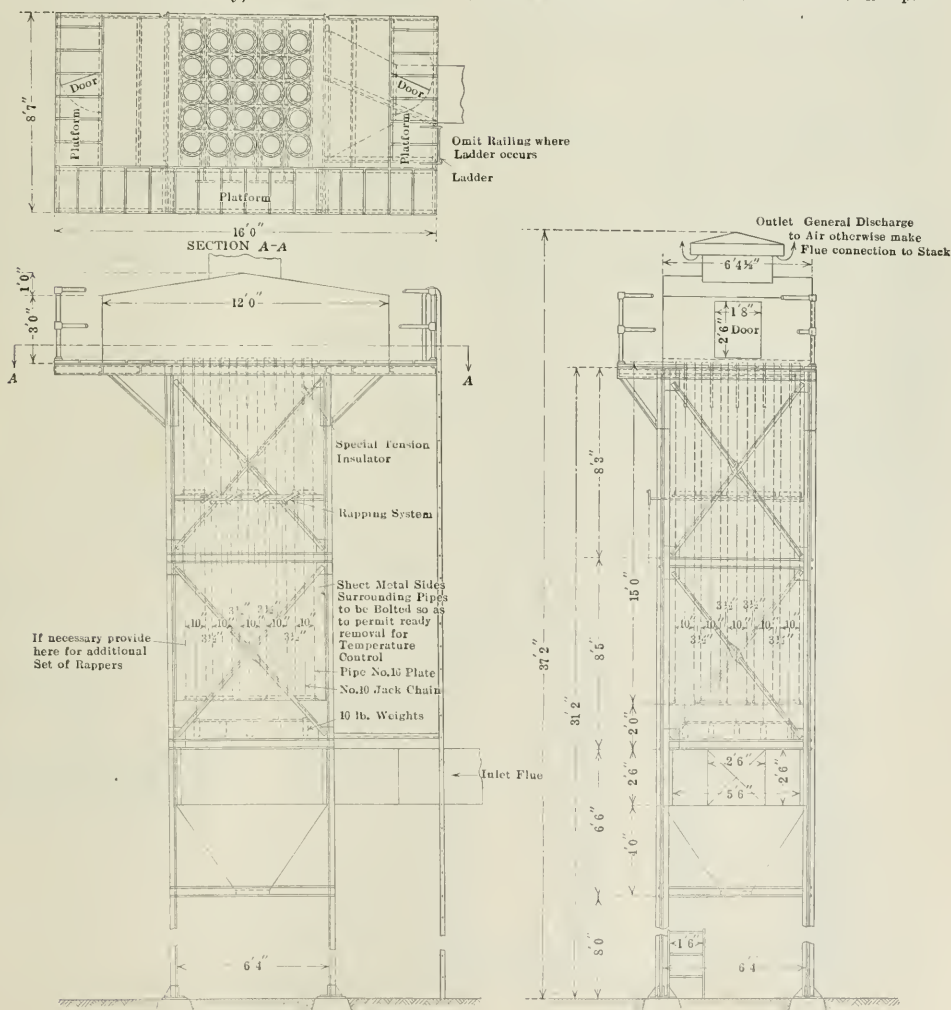
ARSENIC-ANTIMONY COMBUSTION IN OXIDE FORM

If another metal such as arsenic is oxidized in the same furnace with the antimony, an antimonate of ar-

senic may be formed which takes on the properties of the antimony oxide. The arsenious oxide combined in this form is insoluble in solutions of either caustic or carbonate alkalis.

From the experience of the author in dealing with an antimony ore containing arsenical pyrites distributed through the gangue rock, it was found that about one-half of the arsenious oxide formed became united with the antimony oxide to form an antimonate, which was insoluble in aqueous alkali. The other half remained as arsenious oxide, and could be extracted by means of an alkaline wash.

As arsenic is sometimes considered a commercial impurity in antimony, an efficient process of elimination is desirable, but the properties of the two metals are so similar that the problem is very difficult. As a refining treatment for the oxide, fractional distillation might be employed successfully, but this has not yet reached the point of commercial application, although the field is quite encouraging. It has been thought that fractional condensation could be carried out in separat-



ing the oxide fumes as they come from the furnace. This has not been found feasible because the gases cannot be cooled uniformly, but even in spite of this some result might be obtained were it not for the formation of the antimonates of arsenic which are condensed with the antimony oxides and not at the lower temperatures of the arsenious oxides. This antimonate can be decomposed by heating to a high temperature so that the re-distillation of the product would seem to be the more likely means of purification.

PRODUCTION OF ANTIMONY METAL FROM OXIDE

In order to reduce Sb_2O_3 to the metal, it would seem at the first glance that it would be only necessary to mix the oxide intimately with the right amount of carbon and heat it to the point of fusion. The difficulty, as far as this method is concerned, is that the antimony trioxide will volatilize before the temperature is reached at which the carbon will combine with the oxide. This can be overcome by adding to the oxide a fusible alkali to so lower the melting point of the mixture that fusion and reduction are effected before volatilization. When the product is in a state of fusion the reducing action of the carbon is very rapid. The amount of carbon required for reduction is that which is just sufficient to combine with the oxygen of the oxide to form carbon monoxide (CO) gas, for as soon as this gas is formed it leaves the furnace. The practice then is as follows: The metallic oxide is intimately mixed with 12 per cent of its weight of finely divided carbon and 6 per cent of sodium carbonate. The more intimately the mixing and the more finely divided the products, the more efficient will be the reaction. This mixture is spread over the floor of a reverberatory furnace and heated in a reducing atmosphere to temperature of from 800 to 900 deg. C.

The sodium carbonate combines with the antimony oxide forming sodium antimonate and carbon dioxide (CO_2). More antimony oxide is fused therein and the carbon then combines with the oxygen within the fusion forming CO and metallic antimony. This action continues until the reduction is complete, the metal being finally covered by a thin slag, composed of sodium antimonate and impurities. This slag will carry a larger percentage of metallic impurities than the original charge, but this refining action is of but a moderate character. The amount of loss in conversion will be, under good practice, from 10 per cent to 15 per cent of the metallic contents and a part of this will have been lost by volatilization in heating the charge. That portion which is lost by vaporization could be recovered by cooling the escaping gases and precipitating the fume. The percentage of alkali used as a flux has been determined empirically and is the minimum amount required to obtain the proper state of fusion.

It is desirable that a reducing atmosphere be maintained over the charge and that the heating be uniform. Under these conditions no rabbling is required.

The usual type of reducing furnace is a flat reverberatory furnace with a bottom sloping toward the tapping end. It has charging doors at both ends, but it is preferable to introduce the charge from a hopper feeding through the top of the furnace. It may be heated by either hot gas from a wood or coal fire or by means of oil burners, the latter being preferable.

The construction of a furnace with which the writer has had considerable experience is shown in Fig. 3.

After the reduction to metal in this furnace is complete, the metal is allowed to run from the tap hole into ladles and is poured into molds to form cakes of about 40 lb. weight. If as soon as the metal is poured, the

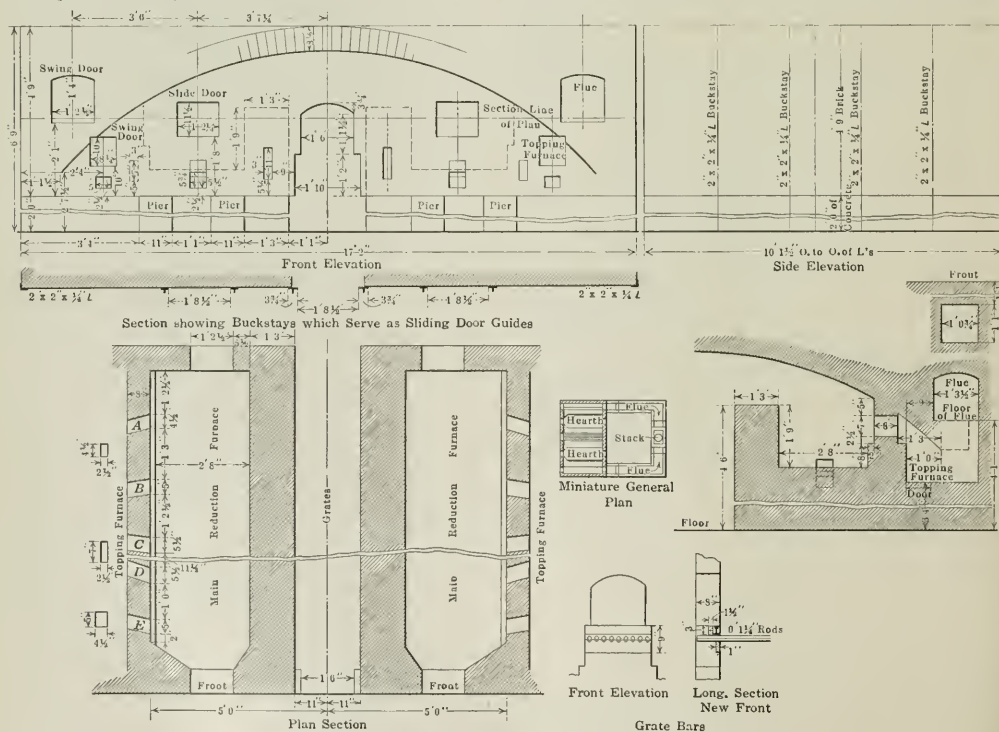


FIG. 3—PLAN AND ELEVATION OF REDUCTION FURNACE

surface of each cake is covered with fusible slag (generally made of sodium antimonate) oxidation of the surface will be prevented and the cake will cool more slowly. This slow cooling allows a beautiful starlike crystallization, similar in appearance to the frost patterns on a window pane, to form on the surface of the cake, and in the trade it is then known as star metal. This starlike crystallization is a special property of antimony and the starred surface has been taken as evidence of the purity of the metal. The presence of some metallic impurities might prevent this starring of the metallic surface, but it has been found that when arsenic alone is an impurity the crystallization is not altered in any way.

ARSENIC ANTIMONY ALLOYS

In fact, the properties of antimony and arsenic are so similar that, for many requirements, they serve practically the same purpose. Alloys of antimony and arsenic are more brittle than pure antimony, but when this metal is used as a hardening agent for other metals, the arsenic and antimony perform the same function.

The relationship between the boiling and melting points of the two metals is peculiar.

The melting point of crystalline arsenic under pressure is somewhat higher than that of antimony, the melting point of which is given by various authorities from 450 deg. C. to 632 deg. C., while similar references give the arsenic a melting point of from 500 deg. C. to 850 deg. C. When the boiling points are considered, however, it is found that crystalline arsenic sublimates at 554 deg. C. and antimony at 1440 deg. C.

If an alloy of these two metals is in a state of fusion and out of contact with air, it would be expected that the arsenic would distill off from the alloy and leave a pure metallic antimony. But as a method of purification this does not succeed, for when the arsenic is only present in quantities of from 2 to 3 per cent. then the pressure of diffusion will just about counteract the pressure of the arsenic vapor, and the distillation does not continue. This fact has been demonstrated by the author in a test where antimony metal containing a small amount of arsenic was heated in a reverberatory furnace at a temperature of about 900 deg. C. for eight to ten hours without reducing appreciably the percentage of arsenic.

Another interesting fact is that metallic antimony, although it will hardly oxidize at all when cold, will oxidize very rapidly when heated in contact with air to the point of fusion. If it should contain a small amount of arsenic, the antimony will be burned off under these conditions at about the same rate as that at which the arsenic will be distilled and oxidized. The antimony oxide fumes are poisonous, as are also those of arsenic, so it is possible that the difficulties of refining arsenical antimony may be to some extent alleviated in the future by developments in the use and application of the product.

In metal produced by the volatilization process, there can be but one impurity and that is arsenic, for the other metals found associated with antimony in its ores are not volatile. The entire refining problem, therefore, in dealing with antimony produced by this method is the disposal of this arsenic with its closely allied properties. The arsenic can be eliminated more easily from the oxide than from the metal, but it involves treatments which increase the cost of production and reduce the yield of product.

The amount of purification will, therefore, depend upon the amount of commercial discrimination against metal containing this particular impurity. It would appear that up to the present time the commercial valuations have been based more upon the analytical deter-

minations of impurities than the physical properties and structure of the metal itself and its value for specific properties.

As already pointed out, one of the chief uses for antimony trioxide is in the manufacture of white enamel. The tetroxide is not suitable for this purpose owing to its infusibility, so that it is necessary that the furnace control be such as to prevent the formation of this higher oxide. This commercial product is tested for its solubility in acids as a means of measuring its fusibility and freedom from tetroxide. The presence of small quantities of arsenious oxide in this material is apparently no detriment, and, in fact, it increases the fusibility of the product, making it easier to handle when the workmen have become accustomed to it.

The commercial opportunities in America for the application of the volatilizing process of antimony recovery are, therefore, quite promising, providing that a sufficient quantity of cheaply mined low-grade stibnite ore is available.

It would only be necessary to follow well defined scientific methods in roasting the ore and recovering the oxide so as to obtain efficient yields, and a stable industry could be established.

Grading of Crushed Stone and Gravel Feldspar, Fireworks and Flour

By Edward S. Wiard

CRUSHED STONE AND GRAVEL

The grading of crushed stone and gravel is an enormous industry. The value of crushed rock in 1914 was \$30,161,766, and the average price per ton was \$0.61. The rocks crushed are granite, which was sold at an average price in 1914 of \$0.76 per ton, having a total value of \$3,975,575. Trap rock sold at an average price of \$0.69 per ton and had a value of \$6,225,805. Limestone in 1914 was valued at \$18,061,881, and cost on an average \$0.55 per ton. Sandstone was valued at \$1,450,767, and had an average value of \$0.82 per ton in 1914. The uses to which the crushed rocks were put was in road making, the value of the total rock used for this purpose being 44.19 per cent, for railroad ballast 20.25 per cent and for concrete 35.56 per cent. In the more elaborate rock-crushing plants notable quantities of sharp sand are produced in the crushing processes, the value of which is included in the figures given under granite and sandstone.

The total value of the gravel produced in the United States in 1914 was \$9,398,897. Probably only a very small proportion of this was graded, though there are important centers where this is done. At Chicago, for example, the gravel grading business is an important

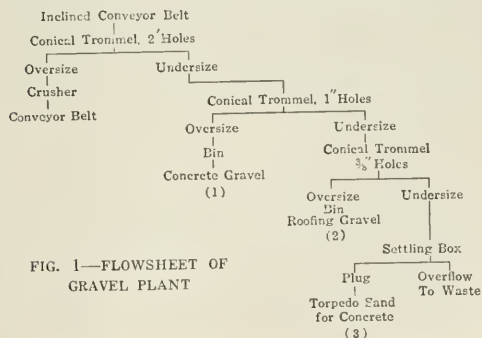


FIG. 1—FLOWSHEET OF
GRAVEL PLANT

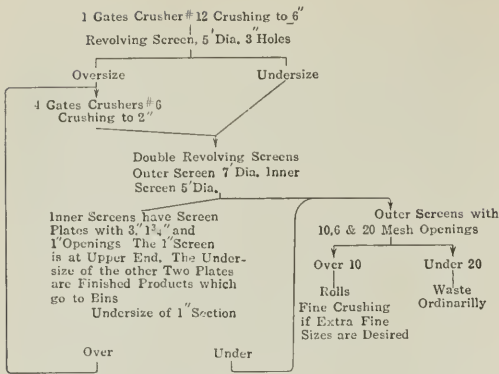


FIG. 2—FLOWSHEET OF ROCK CRUSHING PLANT

one and a plant capable of treating from 600 to 1000 tons per day is illustrated by its flowsheet in Fig. 1. The three principal products made, it will be noted, are large pieces of rock for concrete, a medium size for roofing and sand for concrete. The process is conducted with water. The gravel beds in the vicinity of Chicago are usually too wet to permit of dry screening, owing to the near presence of Lake Michigan.

The crushed stone industry has grown from an output amounting to about \$6,000,000 in 1900 to the large figure which has already been given. This growth has been due to the greater use of cement in concrete and the growth and improvement in public roads, due to the demand created by the automobile industry. The typical flowsheet of an Eastern rock-crushing plant of 3000-5000 tons daily capacity is shown in Fig. 2.

One of the problems of concrete making is the question of filling of voids. Experimental work undertaken at many places has shown that the amount of cement can largely be reduced by mixing with the rock and sand a certain proportion of very fine material without reducing the strength of the aggregate. Fig. 3 illustrates a more perfect theoretical mode of void filling. The three large spheres have a central void which can be filled, first with the largest sphere which can be placed in it. The remaining spaces can be filled with the largest spheres which they contain, etc. Eventually there will remain no voids.

In filling voids in this way with irregular fragments conditions would be obtained which would only approximate the arrangement shown in the diagram. With screens the filling of voids in the way indicated in the diagram would probably cause a great waste of material, since, as a glance at the diagram will show, the jump from the largest size to the next lowest is very great. The McKesson machine may, however, offer means of selecting numbers of sizes which can be grouped for a very close filling of the void. The bond in all void-filling problems is the most expensive material to use.

A further difficulty which would ensue on attempting to realize the arrangement shown in the diagram or something similar with irregular shaped grains would be the difficulty of making the grains take the most compact posi-

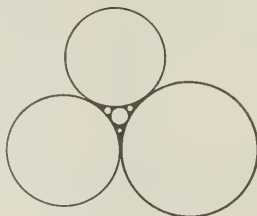


FIG. 3—FILLING VOIDS

tion. The more thorough the mixing, which should be of such a character that the component parts of the aggregate will not tend to separate into layers according to gravity or size, the more nearly the aggregate would attain a symmetry similar to the one shown by the figure.

FELDSPAR

This material is used for making pottery, enamel ware, enamel brick, electrical wares, and as a constituent part of both body and glaze in true porcelain, white ware, vitrified sanitary ware, and in underglaze and glaze in so-called porcelain sanitary wares and enameled brick. For pottery purposes the feldspar must be free from iron-bearing minerals, biotite, garnet, hornblende, etc., and have little or no mica. For the finer grades of pottery the quartz limit is about 5 per cent. For ordinary pottery the quartz may run as high as 15 to 20 per cent. The use of feldspar in emery wheels has been mentioned. A small amount of very pure feldspar is used in opalescent glass. Extra select feldspar is used in the manufacture of false teeth. Some is used for scouring soaps and has the good quality of being slightly less hard than glass. It thus will not scratch glassware, and this kind of soap is valuable for cleaning windows.

The raw feldspar from the quarry is fed to a buhr mill, the stone being from 3 to 5 ft. in diameter and 1 to 1½ ft. thick. The spar is crushed between the stone and the bed. Following the mill crushing the spar is screened, the oversize returning to the mill and the undersize passing to tube mills. The buhr mill consequently works in a closed circuit.

For pottery purposes the spar is usually ground from 4 to 6 hr., when nearly all will pass a 200-mesh screen (96 to 98 per cent). What is called No. 3 spar is not ground so fine, only about 75 per cent of this grade will pass a 200-mesh screen. This grade of spar remains in the mill but two or three hours. For abrasive soap the spar is ground 10 hr.

Just as with cement there is a problem awaiting solution and this problem has to do with the advisability of making a closed circuit with the tube milling.

A wet process for separating the very fine spar would increase the cost of production, as it would be necessary to disintegrate the dry caked spar, and this method is used only in a few mills.

An effective air separation might be employed where an extra-fine grade of high-grade spar was wanted, but it does not seem to have been employed at any of the mills.

The chief sources of feldspar lie in the states of Connecticut, Maine and a portion of Pennsylvania, Delaware and Maryland. The best grades are sold as high as \$5 or \$6 per ton in the crude condition and over \$10 ground. Excellent feldspar also comes from Canada. The production of domestic spar was 135,419 tons in 1914 and valued at \$629,873. The production of crude spar was 85,905 tons, valued at \$263,476. The production of ground spar was 49,514 tons, valued at \$366,397.

FIREWORKS

In making the stars for roman candles and other fireworks brass screens are used to separate the sizes made, usually six in number.

FLOUR

The cleaning and grading of wheat will be discussed in a later article. The old mode of producing flour was by the use of mill stones, the aim of the miller being to get as large a bulk of floury material as possible at one operation. The result of this was that the flour con-

tained much worthless material, lacking in nourishment, harmful, such as germs and crease dirt.

The various breaking and screening operations which take place in a modern flour mill are of very great complexity, every mill being different in the types and mode of arrangement of machines employed.

In the large mills the flowsheets or diagrams showing the position and type of machines used are very jealously guarded.

Wheat is a fruit and not a seed as is most commonly thought. A magnified section of a portion of wheat berry is shown in Fig. 4. The outer part marked *B* is considered to consist of four more or less branny coats, the inner one of which has some food value; but owing to its color it is eliminated as far as possible from domestic brands of flour. The interior part *C* forms the bulk of the household flour. *D* is the germ or true seed. This is a tough, oily body which if not removed becomes rancid and interferes with the keeping quality of the flour.

In breaking by rolls the germ is flattened and easily removed by a later screening operation. The placenta is a cord passing upward between the outer coats, its function being to furnish a passage through which liquid nourishment may enter the berry during the stage of growth. The placenta acts as a filter, removing im-



FIG. 4—SECTION OF THE LOWER PORTION OF A WHEAT BERRY MAGNIFIED

purities from the sap. The impurity which thus collects is called crease dirt and will discolor the flour if not removed.

It will now be understood why a simple grinding process, followed by screening, will not yield the best results in flour making. A further reason lies in the varying demand of the trade. Household flour must be very fine and white, while bakers' flour must be strong, quick-rising, and hence contain a large proportion of gluten. The glutenous material, as the diagram shows, lies outside the starchy white center.

To obtain the highest grade of domestic or household flour the mode of procedure would be as follows: The prepared and cleaned wheat berry passes to the No. 1 break rolls, where after screening in a screen with gentle action such as a gyratory bolter would yield some flour of a coarse size containing bran adhering to the interior portion of the berry and suitable for further rolling. Some true middlings would also be formed contaminated with some loose and adhering bran. Middlings resemble the familiar breakfast food "Cream of Wheat" and are largely granules of the interior white starchy part of the grain. These middlings are then sent to a purifier, which is a screen with an air current passing through it to carry away the light loose bran. The purifier would at the same time yield two sizes of middlings and a very branny product. On again rolling the coarser part of the middlings, and

screening in a screen with a strong action such as a centrifugal reel, a very high grade domestic flour is obtained containing a minimum of branny impurity and a fair amount of gluten.

The flour from the first break and first screening yields a cheap, good, strong bakers' flour after a number of other operations. An outline of the beginnings of an elaborate flowsheet has been given, and it would be impossible within the limits of articles such as these to carry the flowsheet further to the production of other grades of flour and by-products.

The various types of screen have been touched upon. Two of the chief events in the mechanics of flour milling were the introduction of rolls about 1850. The invention seems to have been Hungarian, and mills employing rolls formerly denominated their process by Hungrainia or Hungarian Patent Processes, etc.

The other great advance came with the introduction of the purifier, the invention of which in 1859 is ascribed to Lacroix, although others almost simultaneously developed inventions along similar lines. These innovations gave a greatly increased yield of salable flour.

Gyrating bolters are used where a gentle action is desired as well as plain reels. For strong action centrifugal reels are employed, particularly where quantity rather than quality is desired, as the strong action of the centrifugal machines will force much material through the apertures, which would not be desirable for a high-grade product. Centrifugal reels are adapted to bolting soft, fluffy material, dusting bran, etc.

Silk cloth and grit gauze are used exclusively in flour milling owing to their freedom from contamination, the ease with which they yield when brushed or rubbed to free the apertures from blinding. In this connection it should be noted that owing to the nature of floury products screening is largely accomplished by a process of blinding and rubbing through the apertures. Another good quality of silk cloth is that it will not wear smooth, but exerts on the products a gentle friction tending to liberate flour or other finished products.

The function of a middlings purifier has been touched upon. This is merely a flat shaking screen housed with means for carrying up through the mass on the screen air currents, thus bringing the light material to the top where some of it is carried off to a dust collector and the balance discharged from them. While the light stock is being held up in this way, chance is given in the bed of material below for the screening out of different size products; the material discharging at the end contains mainly impurities. Means are also provided for keeping the screen from blinding.

There is one grading problem in the mills which is not regarded as of much moment by practical flour millers, and that is the grading of the wheat before rolling. The rolls are all set with faces at fixed spaces apart; consequently, with some variation in the size of the berry some are more severely broken up than others. The Rich grader has been proposed for this service and a description of this machine will be found under the head of malt. It has no application in the flour mills. The McKesson machine may have a similar application in an improved form.

Industrial Exposition at Springfield.—The Industrial Exposition and Export Conference which was originally to have been held May 26 to June 2, at Springfield, Mass., has been postponed to June 23-30, to meet the wishes of a number of manufacturers who desired to have the later date. Mr. F. H. Page, president of the National Equipment Company, is chairman of a general committee.

Recent Metallurgical and Chemical Patents

Electric Furnaces

Continuous Induction Furnace.—An electrical induction furnace for melting metals, and for smelting iron and other ores, is patented by PARVIN WRIGHT, of Vancouver, B. C. In smelting work the charge is fed continuously into smelting furnaces adjacent a crucible. The different smelting furnaces overflow into the same crucible and the molten metal is withdrawn continuously from the crucible. The furnaces and crucible are heated by induction. It is claimed that the continuous operation of the furnace gives a constant consumption of current in the furnace and maintains a constant load on the generator. (1,218,151, March 6, 1917.)

Electric Steel Furnace Regulation.—A method of regulating the positions of the electrodes in an arc furnace, either automatically or by hand is patented by JOSEPH L. DIXON of Detroit, Mich. In arc furnaces where two-phase current is supplied through four movable electrodes it is desirable to preserve uniform heating conditions by keeping the lengths of the four arcs formed under the electrodes as nearly equal as possible. In such an arrangement each pair of electrodes belongs virtually to an independent single phase circuit, since all the current passing through either member of either pair finds its way back through the other member of the same pair. In consequence, an indicator of changes in current strength associated with either or both members of a pair would not alone give a significant indication, since any change of current shown is due to a change in the sum of the lengths of the pair of arcs and not to any change in either arc alone. Such a system must therefore be furnished with both ammeter and voltmeter apparatus, whether for hand or automatic regulation. This greatly complicates the problem of regulation and makes proper efficient handling quite difficult. The present patent proposes to avoid these objections by supplying two-phase current from two transformers having divided secondaries, and so connecting the eight secondary terminals among themselves that the resulting vector diagram becomes a square, which may be considered as a special case analogous to a delta connection. The four movable electrodes are then connected so that they appear at the four corners of the square in the vector diagram. By employing the arrangement described, the current leaving any one of the four electrodes does not return exclusively through any single electrode. Consequently, if any of the four approaches the bath too closely or does not approach it closely enough, a single ammeter related exclusively to the supply conductor of that electrode will indicate an increase or decrease of current betraying the existing difficulty. Such an ammeter can then either serve to guide hand control or to govern automatic control in any well-known manner, without the necessity of using voltmeters. (1,214,763, Feb. 6, 1917.)

Heat Treating Furnace.—FRANK T. COPE of Alliance, Ohio, patents an electric furnace in which the trough containing the resistor material is located in the heating chamber of the furnace and is constructed with air spaces around it for air circulation. The patent is assigned to the Electric Furnace Company, of Alliance, Ohio. A longitudinal sectional view of the furnace is shown in Fig. 1. The base of the furnace 1 is of metal and the hearth 3, side walls and end walls are made of fire brick. The refractory trough 8 contains the granular refractory, resistance material 9, and electrodes 10 embedded near each end of the trough. The refractory trough is supported upon a series of transverse supporting walls 11, and the trough is spaced away from the side walls and roof so as to allow the air to circulate

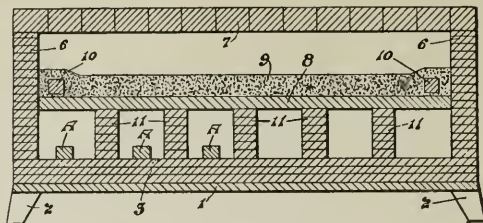


FIG. 1—LONGITUDINAL SECTION OF FURNACE

around the trough, preventing excessive heating of the trough upon any one side and causing a more even temperature. The billets to be heated are shown at A. (1,218,058, March 6, 1917.)

In another patent of THADDEUS F. BAILY and FRANK T. COPE a terminal is described which is designed to prevent the electrode from oxidizing at the point where it enters the furnace. This is accomplished by inclosing the electrode in a sheet metal box and filling in the space with flake graphite, carborundum or charcoal so that it completely surrounds the electrode. The outer extremity of the box is supported and insulated from the furnace by means of a block of fire clay supported by brackets from below, and by fireclay joints. Electrical connection from the electrodes to the cables is made by laminated copper strips. The granular material will be gradually oxidized and can be renewed from time to time. (1,218,042, March 6, 1917.)

Iron and Steel

"Combined Acid and Basic" Steel Process.—A process of making steel from relatively cheap materials is patented by GEORGE G. MCMURTRY of New York City (Patent assigned to U. S. Steel Corporation). The basic and acid processes are combined and a neutral furnace lining of zirconia is used. The process may be carried out in either an open hearth or electric furnace. The procedure for an openhearth furnace is given as follows: "Pig iron and scrap with limestone and iron ore form the charge. The lime and ore form a slag which oxidizes and eliminates from the bath phosphorus, silicon, manganese, carbon, etc. This slag is removed from the metal, either by scraping off the slag or by tilting the furnace and allowing it to flow away, or by removing the molten metal from the furnace and replacing it in the furnace minus the slag covering. A second slag, acid in character, is then added consisting, for instance, of silica sand, and the operation finished in the usual manner of working the acid open hearth process.

In an electric furnace the procedure is given as follows: "I place in an electric furnace, which is lined with a neutral refractory material, such as zirconia, the metal to be treated. I provide a slag, consisting of lime and iron ore, by which various metalloids are eliminated. I then remove the slag in one of the ways mentioned in connection with the open hearth procedure. I then add a slag very basic in character, consisting usually of lime and fluorspar, but which may also contain a certain amount of silica. By means of a reducing agent, such as carbon, silicon, aluminium, etc., I reduce oxides from the slag and, at the same time, remove sulphur from the metallic bath, by treating it in the slag as calcium sulphide. The slag extracts a certain amount of sulphur from the bath, which forms calcium sulphide and which tends to return very readily into the bath. The powdered carbon or similar reducing agent thrown on the slag combines with the sulphur of the calcium sulphide therein and prevents its return to the bath.

There is thus a continued extraction of sulphur from the bath, without the usual returning of the same, and consequently a desulphurization of the bath. I then remove this basic slag from the bath of molten metal and thus get rid of the sulphur, leaving in the bath any metals which may have been reduced from their oxides. I then add an acid slag, consisting for instance of silica sand, and proceed in the usual way to finish the refining according to the acid process, except that in this case the heat necessary is obtained from the electric arc instead of by the combustion of gases in the melting chamber of an open-hearth furnace." (1,217,972, March 6, 1917.)

Regenerative Annealing Furnace.—An annealing furnace with regenerative chambers and for use with either gas or oil fuel is patented by ARTHUR L. STEVENS of Chicago, Ill. The furnace is made of the usual brick work walls and roof and reinforced by a structural frame. It is built upon a concrete foundation, and the front end of the furnace contains a door which can be raised to admit a truck which runs upon rails and which has a fire-brick platform. On this truck the material to be heated is placed. The truck and its load are borne by the foundation, the furnace structure not being subject to any stress. Arches are eliminated except for the roof. The whole furnace including the regenerator is above ground. The combustion chambers are on the sides of the furnace between an outside and inside wall, and the material is heated mostly by radiation, no flame coming in direct contact with it. The regenerative chambers are at the ends of the furnace. (1,219,499, March 20, 1917.)

Oxygen and Hydrogen

Electrolytic Oxygen and Hydrogen Cell.—A diaphragm cell for the production of oxygen and hydrogen is patented by R. J. J. MUELLER of Chicago, Ill., and E. G. ROWLANDS, of Milwaukee, Wis. The patent is assigned to the Universal Oxygen Company, a Wisconsin corporation. The casing of the cell is made of cast iron which also acts as a cathode together with other cathodes consisting of a number of cast iron plates suspended in the cell and parallel to the sides. The casing is open at the top and is provided with a cover which is insulated from the tank, and contains the terminals of the anodes. The anodes are tubular, closed except at the top and bottom. This structure is claimed to produce an automatic circulation. The cathode plates and tubular anodes do not extend to the bottom of the cell, but leave a clear space. The bottom of the cell is coated with paraffin and a glass plate laid upon it. This is to prevent the current from going from the anode to the bottom of the cell and thus generating hydrogen which would pass through the bottom of the diaphragm into the oxygen space above. The diaphragm is made of non-metallic woven fabric such as felt or asbestos treated with paraffin. A diaphragm encloses each positive electrode, but is open at the bottom to allow of solution circulation, but the bottom of the diaphragm is lower than either electrode. (1,219,843, March 20, 1917.)

Generation of Oxygen.—A method of generating pure oxygen for use in such places as on submarine boats is patented by JOHN F. SANDERS, of Roseburg, Oregon. The patent is assigned to O. P. Coshov of Roseburg, Oregon. In order to prevent contamination of the oxygen with hydrogen, which is dangerous, use is made of an electrode which absorbs hydrogen. A compound cathode consisting of palladium sponge or palladium black with some rhodium, is stated to absorb the most hydrogen. Rhodium is stated to be more important as a catalyst than as an absorber of hydrogen. When the cathode has become saturated with hydrogen

it is submerged in ammonium persulphate and is re-stored again to its absorbing condition. The rhodium acts as a catalyst to combine the hydrogen of the cathode with the oxygen of the persulphate. The same kind of plate is used for the anode as for the cathode. Pure water is used for the electrolyte. (1,218,584, March 6, 1917.)

Potash

Potash from Feldspar.—Henry Blumenber of Los Angeles, Cal., patents a process of rendering soluble the potash in orthoclase by heating with sodium nitrate. Orthoclase, pulverized to pass 200 mesh and sodium nitrate of the same fineness are mixed in equal proportions and heated in a closed cast iron crucible to 1200-1500 deg. Fahr., until completely fused. The nitric oxide fumes are withdrawn at the top and used for making nitric acid or are absorbed in lime to form calcium nitrate. The heating is stopped when no more nitric oxides come off, usually requiring about thirty minutes. The end product in the crucible is a sodium potassium aluminium silicate which is withdrawn through a valve at the bottom. This is pulverized after solidification and will contain about 7 to 10 per cent water soluble K_2O . It may be used as such or concentrated further by extracting the sodium, potassium and aluminium with sulphuric acid. (1,214,003, Jan. 30, 1917.)

Synopsis of Recent Metallurgical and Chemical Literature

Calibration of Viscometers.—The Bureau of Standards has conducted considerable work on the subject of viscosity and has just published Scientific Paper No. 298, entitled "Standard Substances for the Calibration of Viscometers," by EUGENE C. BINGHAM and RICHARD F. JACKSON. The measurement of the viscosity of a liquid is frequently an indication of its quality. For example, many grades of oils are tested and classified according to their viscosities. The viscometers used in performing these tests are constructed in a great variety of ways and yield very different results unless controlled by liquids of accurately known viscosities. The standards proposed are pure water, mixtures of alcohol and water, and solutions of sugar in water. All previous measurements of water and of alcohol and water were carefully recalculated by the authors and the viscosities of sugar solutions were measured for three different strengths at temperatures between 0 and 100 deg. C.

The following summary of the work is given by the authors:

"For the purpose of the calibration of viscometers, there is need for one or more liquids whose viscosity is greater than that of water, which can be easily obtained, and whose viscosity is known with a considerable degree of certainty.

"Of the suitable substances ethyl alcohol-water mixtures and sucrose solutions each possess certain marked advantages. The viscosities of the former are well known, there existing data by several observers which agree as well as can be expected; but the correctness of the data for the latter has been questioned. Hence we have redetermined the viscosity of a 20 and a 40 per cent solution by weight and have in addition measured the viscosity of a 60 per cent solution from 10 deg. to 95 deg. C. The viscosities obtained by us are generally somewhat higher than the values obtained hitherto, but we have every reason to believe that our values are worthy of confidence.

"The existing data on the viscosity of water have been reviewed in order to correct it so far as possible

according to our present knowledge. The viscosity and fluidity of water for every degree Centigrade from 0 to 100 has been calculated.

"The advantages and disadvantages of expressing viscosity in absolute or specific units have been compared. The suggestion has been made by expressing all data in terms of the centipoise (the one-hundredth part of the cgs unit), the absolute viscosity of substances would be practically also the specific viscosity, provided that we take water at 20 deg. as the standard. We find the most probable value for the viscosity of water at 20 deg. C. to be 1.005 cp."

Steel Industry in Germany.—The report of the German Steel Union for the year ending June 30, 1916, contains interesting data showing the ratio of various products made during the second year of the war. The following data from the report are taken from *Engineering* (London):

"In what may be called peace commodities, railway material and sections, there was a further retrogression in manufacture, whilst in the half-finished products wanted for war material there was an increase of 18 per cent. The quantities of half-finished products dispatched during the year amounted to 64.12 per cent of the allotment, against 54.14 per cent for the preceding year. On the other hand, the figures for railway material receded from 68.41 per cent for 1914-15 to 61.88 per cent for 1915-16, and those for sections from 35.48 per cent to 32.31 per cent. The prices during the year under review had been materially raised owing to increase in cost of manufacture and to the position of the market, the advance during the year amounting from 15 to 17.50 marks per ton for the different goods. Export prices had also been much higher, but in the interest of the army requirements exports had been much reduced and had been subject to special control. In the former, normal times about one-third to four-fifths of the output of half-finished products and railway material were exported. The export of half-finished products during 1915-16 receded to 9.66 per cent, against 23.80 per cent for the previous year. For railway material and sections the figures were respectively 11.28 and 15.64 per cent and 20.81 and 21.11 per cent. The exports of the different commodities, in percentages of the total quantities for the last eight years, were:

Year	Half-Finished Products, Per Cent	Railway Material, Per Cent	Sections, Per Cent
1908-9	36.27	25.25	22.47
1909-10	34.00	34.47	33.45
1910-11	36.92	44.08	25.64
1911-12	39.69	37.19	25.61
1912-13	28.14	33.97	27.93
1913-14	45.87	31.64	24.93
1914-15	23.80	15.64	21.11
1915-16	9.66	11.28	20.81

"As regards railway material the home contracts, in spite of some supplementary orders from the Prussian and the Imperial State railways, showed a decrease, as far as these railways were concerned, whilst the other German State railways, partly at least, placed higher orders than during the preceding year. A fresh three years' contract was concluded with the Prussian State railways last June (for the year 1917-1919) on the basis of 129 marks (£6 9s.) per ton for rails. The business in rails for mining purposes had been satisfactory. As far as the foreign trade was concerned some satisfactory contracts in heavy railway materials were secured from neutral States and the Balkans, both as regards quantities and price. As the building industry remained generally almost at a standstill, the demand for sections naturally was affected, but there was a fair demand from railway carriage manufacturers and from engineering shops. From abroad the demand was very

quiet during the first half of the year, but in January it began to increase, and became active. Regard for the home market, however, coupled with the impossibility of giving prompt delivery, impeded the trade. The business expenses during the year to be defrayed by the combine amounted to 1,835,593 marks, against 1,649,746 marks for the preceding year."

Survey of California Oil Fields.—The first annual report of the State Oil and Gas Supervisor of California has recently been issued. It covers the last half of 1915 and the first half of 1916. The law establishing the Department of Petroleum and Gas of the State Mining Bureau became effective Aug. 9, 1915. The department is under the general jurisdiction of the State Mineralogist, who is authorized to appoint a supervisor to supervise the drilling, operation, maintenance and abandonment of petroleum or gas wells, in order to prevent damages from infiltrating water and other causes. This report covers the first year's operations of this supervisor and his assistants, and shows that most successful work was accomplished. The following paragraph from the report explains the conditions as the bureau found them:

"The work of the bureau during the past year has not been directed to a study of operating conditions, but observation of them could not well escape notice while the regular work was being carried on. In fact, a most excellent opportunity has been afforded to compare various methods. This broad field of observation justifies the statement that *there is probably no large business so inefficiently conducted as is that involved in the production of oil in California*, notwithstanding the fact that mechanical operations here seem to be more advanced and improved than in any other part of the world. The annual losses, due to unsystematic work and actually paid out of pocket, amount to hundreds of thousands of dollars. Bankruptcy would speedily follow such management in any line of business, not dependent upon either a most abundant natural supply of crude material or fresh infusions of capital from other sources. These two alleviating conditions cannot be expected to continue indefinitely."

The extent of the oil industry in California is given roughly as follows: There are 80,702 acres of proved oil land, with a market value of at least \$1,000 per acre, or a total of \$80,702,000. There are approximately 2000 miles of pipe lines costing on an average of \$20,000 per mile, or a total of \$40,000,000. There are nearly 30 refineries, with a total daily refining capacity of about 175,000 barrels of crude oil and representing a total investment of probably \$15,000,000. There are approximately 40 tank steamers serving the California oil fields, having a total carrying capacity of about 1,500,000 barrels and costing not less than \$15,000,000. The producing oil wells number over 7000 and have cost over \$100,000,000. Therefore the total investment in the oil business, without considering such railroads, towns, electric lines, water systems and other improvements constructed solely on account of it, represent an expenditure of at least \$250,000,000. There is a constant annual addition to these expenditures due to the drilling of new wells, which during the past fiscal year amounted to about \$6,000,000 for 400 wells. Annual expense also involves deepening, redrilling and abandoning wells, which during the past year probably cost nearly \$1,000,000. The work of the State Mining Bureau in protecting the oil fields against infiltrating water depends upon full and complete logs of wells and the law requires that they be furnished the bureau. Where poor records were encountered it was usually found that the operator had not kept daily reports. A short description of the method of extracting gasoline

from natural gas by absorption in oil is given, and it is stated to be worthy of the attention of California operators. A full description of this method was given in this journal June 1, 1916, page 651-60. Gasoline is extracted from natural gas at present in California mostly by the use of compressors.

Industrial Gas Burning.—A method of making a gas burner which is stated to give complete combustion of the gas is described by F. S. SINNATT in the Journal of the Municipal School of Technology (England) Vol. 8. It is extremely desirable that no carbon monoxide be left unburned. This is accomplished in the ordinary domestic burner by admitting more air than is required

of burner, the number of the disks being varied according to the volume of gas to be consumed. Fig. 1 shows a brazing burner and Fig. 2 a metal melting burner.

Hydroelectric Exhibit of Canadian Pacific Railway

An interesting electrical and electrochemical exhibition was held at Montreal, Canada, from March 12 to 31, by the Canadian Pacific Railway. The exhibit was arranged by the Natural Resources Survey of the Railway of which Arthur D. Little, Ltd., are directors, and was held in the latter's industrial museum at 137 McGill Street.

The object of the exhibit was to indicate the large amount of waterpower available for development in Canada and to show the various electrochemical products which can be produced, and which have been produced from the electric current generated at Niagara Falls and other points in the United States and Canada.

Attention was called particularly to the importance of the electrochemical and electrometallurgical products to our industrial life. Practically all of the important products were shown, including ferroalloys, calcium carbide, cyanamide, caustic soda, chlorine, bleach, oxygen, graphite, electric steel, etc. Around each primary product the related products were grouped into whose manufacture the primary product entered, for instance, acetylene made from calcium carbide and cyanide made from metallic sodium. In this way the importance of the electrochemical products was brought out. Electric lighting was also represented by an exhibit of various kinds of lamps.

It was shown that the water powers of Canada at present commercially available are widely distributed. A map showing those over 5000 hp. and adjacent the Canadian Pacific line had been prepared. More than ninety separate waterpowers are shown on this map aggregating about 7,500,000 hp. Of this amount about 750,000 hp. or 10 per cent has been developed.

Many industrial concerns from the United States and Canada loaned products and specimens. Among these companies were the following: Acheson Graphite Company, American Cyanamid Company, Henry Birks & Sons, Ltd., Canadian Aeroplanes, Ltd., Canadian Car & Foundry Company, Ltd., Canadian Electro Products, Ltd., Canadian General Electric Company, Ltd., Canadian Pacific Railway Company, Angus Shops, Canadian Salt Company, Chemical Products Company, East End Garage, Electric Reduction Company, Foote Mineral Company, Hamilton & Hansell, Halcomb Steel Company, Harbison-Walker Refractories Company, Lyman, Ltd., D. W. Massie of Munderloh & Co., Ltd., Mc-

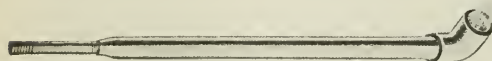


FIG. 1—BRAZING BURNER

to oxidize the gas. The addition of an excess of air, however, leads to two sources of waste, first a lowering of the flame temperature, and second, an increase in the heat units carried away in the waste products. Many of the objectionable features of gas as a means of heating metal or other cold surfaces are overcome to a degree by mixing the gas with air under slight pressure previous to its arrival at the point of combustion. This yields a form of blow-pipe flame, and it is possible by this method to add to the gas the exact volume of air required for complete oxidation. Back explosion must be prevented, and this is done by burning the mixture on a thick gauze or perforated plate, and by increasing the velocity of the gas. A combination of these two processes comprises the author's method. He overcomes many of the difficulties of burning gas completely in this manner by making the perforated plate or gauze concave on the side upon which the gas is burning. The perforations should have a common focus. The whole of the flames burning on each of the separate perforations are thus made to pass through a common point, or the flames are focused. The effect of this treatment is to overcome within wide limits any variations in the composition of or the pressure of the gas. It is nearly impossible for the gas to escape combustion owing to it having to pass through the common focus. The combustion of the gas is in a degree self-induced, and the rate at which the gas burns

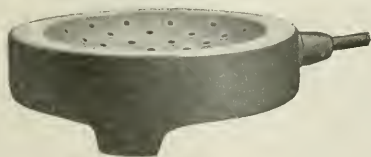
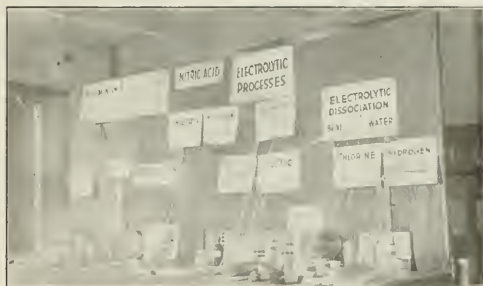


FIG. 2—METAL BURNER

on the plate is increased by the thorough mixing which occurs. Differences in the size of the perforations cannot influence the flame to the extent they do on a flat perforated plate. The degree of concavity required for different pressures and for fuel gases of different compositions was determined experimentally for the gases which have been burned by the system. The size of the perforations and the thickness of the metal of the plate are factors which influence the concavity necessary for any particular gas. At present the method adopted, practically, is to use small disks about half an inch in diameter and to fit these into any type



PART OF CANADIAN PACIFIC RAILWAY ELECTRO-CHEMICAL EXHIBIT

Gill University, Department of Chemistry, Montreal Light, Heat & Power Company, Montreal Water & Power Company, Mount Union Refractories Company, Nitrogen Products Company, Northern Aluminum Company, Norton Company, Norton Laboratories, James Robertson & Company, Ltd., Schoellkopf Aniline & Chemical Works, Inc., Shawinigan Electro Metals, Ltd., Snyder Electric Furnace Company, Standard Alloys Company, Fred Thompson Company, Ltd., Titanium Alloy Manufacturing Company, Tivani Electric Steel Company, Watson Jack & Company, Ltd.

New Electrocyanide Process

A new electrocyanide process which is claimed to amalgamate the gold values in the ore directly from the cyanide solution and to regenerate the cyanide has been developed by Messrs. Sill & Sill, mining and metallurgical engineers of Los Angeles, Cal. The apparatus used is the electrocyanide pan, in which the pulp is thoroughly agitated and aerated in cyanide solution and simultaneously subjected to the action of an electric current, whereby a rapid dissolution and a cathodic amalgamation of the precious metals in the ore is secured.

The pan is 15 ft. in diameter and 30 in. deep. Through the center of this pan a small casting projects which permits the passing of the working shafts. The bottom of the pan is practically completely covered by an amalgamated copper plate, to which mercury is added automatically in the course of operation. About 5 in. above the copper or cathode plate is suspended a cast-iron plate equal in area to the copper plate. This cast-iron plate is divided into two annular rings, the outer one having 60 and the inner one 40 per cent of the anode area. On the lower side of each anode ring wooden paddles are fastened radially, about 5 ft. apart, the bottom of the paddles being a couple of inches above the amalgamated copper cathode.

These annular anodes are revolved in the same direction and independently by means of pulleys, gears and a solid and hollow shaft so that any midway point of the inner ring travels practically the same number of feet per minute as the corresponding point on the outer ring. The motion imparted to the pulp by the annular rings and the paddles is a compound rotary one, which causes the pulp confined between the anode and the cathode to circulate in a uniform spiral movement in an outward direction. The ore is thus kept in a perfect state of suspension.

The centrifugal force imparted by the paddles causes the pulp, on reaching the outer edge, to rise between said edge and the outer edge of the outer anode to a height of approximately 16 in., retaining the rotary motion imparted by the paddles and endeavoring by gravity to seek the lower level at the center of the pan. The resultant motion is in a downward and inward spiral until it passes over the inner edge of the inner anode near the center cone, where it again meets the paddles and the cycle continues.

The air required for aeration of the pulp is supplied at the periphery of the pan and on a level with the copper cathode by means of twenty jets uniformly distributed. Figs. 1 and 2 show sections of the electrocyanide pan.

The capacity of the pan depends entirely on the character of the ore treated. With the exception of clayey ores the dilution for the ores is one to one. The pan charge under normal conditions is 7.5 tons of dry ore by weight. If the dilution is one to one and one-half, the charge is 6 tons. The time required varies between one to twelve hours, but generally the operation may be completed in two and one-half hours. Considering the factors mentioned, the maximum capacity varies from 15 to 90 tons per day. On the average run of ores, however, the capacity is from 36 to 60 tons per day.

The electrochemical part of the process is stated to be as follows: In treating a 7.5-ton pan charge holding the same weight of water with the requisite amounts of lime and cyanide, finely crushed salt is added until the ammeter reads 300 to 400 amperes with a voltage of 9.5 to 10 volts. The sodium ions are precipitated on the amalgamated cathode and caustic soda is formed. This then combines with the acid radicals in the electrolyte and thus protects the cyanide from compounds which the lime does not readily neutralize very effectively.

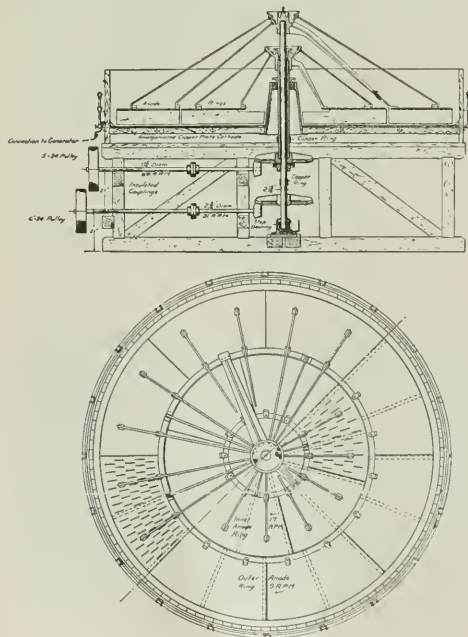
Very little mercury is lost during the process. If there is some mercury in the electrolyte it readily yields to the combined electrolytic and cyaniding action, whereby it is electrochemically precipitated onto the cathode.

An average sized pan will have its power distributed as follows: The total power required for a single pan is from 6.1 to 8.1 hp., of which 0.6 hp. is for mechanical agitation, 1 to 1½ hp. is for compressed air and 4½ to 6 hp. is for the electrolytic process. The compressed air for aeration is used at 100 lb. pressure.

It is claimed for the process that it will treat successfully heavy manganese ores, lead, zinc and copper carbonates carrying gold and silver, pyritic gold ores and arsenical pyrite carrying gold and silver.

Among the advantages claimed for the process are the elimination of filtering devices and of zinc precipitation, making the handling of very clayey ores possible.

Celluloid Making in Japan was very little profitable until 1914, but at present the only manufacturer is extremely busy. He exports to England, France, Russia, America, Australia, China, etc. The value of celluloid articles made in 1914 was \$1,500,000.



FIGS. 1 AND 2—THE ELECTROCYANIDE PAN

Book Reviews

Elements in Mineralogy, Crystallography and Blowpipe Analysis. By A. J. Moses and C. L. Parsons. Fifth edition; octavo (13.5 x 22.5 cm.), 575 illustrations, 631 pages. Price \$3.00 net. New York: D. Van Nostrand Company.

This well-known and much-used text-book is, in this edition, better than ever. There is no need to review its merits in detail, but the 200 additional pages and the many parts which have been rewritten deserve mention. The additions are of new groups and species, particularly those which have recently acquired economic importance; discussion of formation and occurrences of minerals, so as to link up more closely with geology; enlarged treatment of crystal-optics, especially with the aid of the polarizing microscope; new determinative tables; a simplified method of identifying crystal forms; a separate chapter on the gems and semiprecious stones. These additions are commendable, except that the optical part is developed much further than anyone but a specialist in mineralogy has time to go. The simplified method of identifying natural crystals by means of axes of symmetry and planes of symmetry is admirable; it is the exact method developed by the reviewer as most practical in his classes in crystallography some twenty years ago, and it is to be hoped that its adoption in Moses' and Parsons' book will assure its universal use.

The determinative tables could be much improved; they are crude and in spots inaccurate. The "key" headings should be reprinted at the head of each numbered division, to avoid constant reference back to the "key"; the blowpipe tests are not as prominent in the classification as their usefulness demands; ordinary qualitative wet tests are often noted where blowpipe tests would be easier, quicker and more certain. The classifying tests, for instance, are often uncertain; *e.g.*, Class I, A is "Black or Nearly," and covers lists 1 to 10, while Class I, B, "Silver-white, Tin-white or Gray," covering lists 11 to 20, includes at least six minerals which are often "nearly black." At the next revision we advise the authors to concentrate attention upon perfecting these determinative tables. As it stands, however, it is a highly useful book.

* * *

Chemical Tests for Minerals. By Arthur J. Burdick. 93 pages. Price \$1.25, postage 7 cents. Beaumont, Cal.: The Gateway Publishing Co.

This little book is described as an aid for the prospector in testing his samples qualitatively on the ground and has been written with that end in view. It gives descriptions of the various ores and specific tests for each of the minerals separately, and the method and tests necessary for making a general examination of the ore. A description is given of the outfit required and considerable helpful general information such as a tabulation of the solubility of the various minerals and a list of the physical properties of the various materials.

Personal

Mr. S. E. Allison, Woolworth Building, has been appointed New York representative of the Certain-Teed Products Corporation of Baltimore, Md.

Mr. James A. Campbell, president of the Youngstown Sheet & Tube Company, Youngstown, Ohio, has returned from Hot Springs, Ark., where he had been enjoying a vacation.

Mr. J. J. Carty, chief engineer of the American Telephone and Telegraph Company, New York City, and

past president of the American Institute of Electrical Engineers, has been commissioned senior major in the Signal Officers' Reserve Corps, the reserve auxiliary of the Signal Corps, U. S. A.

Mr. Harrison W. Craver, formerly chief librarian of the Carnegie Library of Pittsburgh, has been appointed director of the library of the United Engineering Societies of New York. Mr. Craven was the guest of honor at a dinner tendered to him on April 4 by the Library Committee of the United Engineering Society at the Engineers' Club.

Mr. Leon O. Hart, electrical engineer for the Driver Harris Wire Company, Harrison, N. J., has recently been appointed assistant treasurer of the company.

Mr. Ralph Hayden has recently resigned as superintendent of regrinding and flotation at Anaconda to accept the superintendency of the Quincy Stamp Mills at Mason, Mich.

Mr. Charles Holzworth, formerly superintendent of the Ella furnace at West Middlesex, Pa., has been appointed general superintendent of the Ella and Claire furnaces at West Middlesex. These furnaces are owned by E. W. Mudge & Company, with headquarters in the Frick Building, Pittsburgh, Pa.

Mr. A. E. Marshall, the well-known manager of The Thermal Syndicate, Ltd., New York City, will shortly sever his connection with that company to become works manager of the Curtis Bay, Md., plant of the Davison Chemical Co.

Dr. John A. Mathews, president of the Halcomb Steel Co., of Syracuse, N. Y., lectured before the Technology Club of Syracuse on March 19 on "The Electric Furnace in Steel Manufacture." He illustrated his lecture with numerous lantern slides.

Mr. L. J. O'Loughlin has recently changed his position from blast furnace engineer at the Cambria Steel Co., Johnstown, Pa., to chief engineer of the Wharton Steel Co., Wharton, N. J.

Mr. Lewis E. Saunders, general manager of the Norton Co., at Niagara Falls, is on a business trip in South America.

Mr. Maurice R. Thompson of the Power and Mining Department of the General Electric Company, Schenectady, N. Y., is making a western trip in the interests of the company. He will spend some time at the metallurgical centers in Arizona, Utah and Montana.

Mr. E. E. Watts, best known as the inventor of the Watts electrolytic zinc process, is now connected with the Consolidated Mining and Smelting Company of Canada, Ltd., at Trail, B. C.

Mr. Arthur E. Wells, metallurgist of the Salt Lake City Station of the Bureau of Mines recently visited Seattle, Wash. While in Seattle he visited the Bureau of Mines station, and from Seattle he went to Tacoma, where he visited the plant of the American Smelting & Refining Company. He then went to Anaconda, Mont., where he was to assist in the installation of apparatus for treating the smelter gases as representative of the Federal Smoke Commission.

CURRENT MARKET REPORTS

The Iron and Steel Market

The steel market experienced no shock from the United States entering the world war. Wall Street appraised the event by a slight decline in stock prices, but that reflected the prospect of earnings being heavily taxed to pay for the war, as far as may be, as we go. The furnishing of steel to the government at much below market prices cannot affect total earnings ma-

terially, the maximum tonnage that could be employed being but a small proportion of the aggregate output. Finished rolled steel is being made at the rate of more than 2,500,000 tons a month, and government requirements as thus far discussed are in terms of hundreds of thousands of tons, spread over delivery periods that in some cases exceed a twelvemonth.

The present and prospective government requirements, however, have exercised an important influence upon the general market situation, not so much on account of the total tonnage of steel involved, as on account of uncertainty in what forms the steel will be required. The industry is highly specialized. The individual stands of rolls have limited ranges. In some cases the range is large theoretically, but small practically when ingot producing capacity has been increasing apace for more than a year and rolling capacity not in proportion. To finish the ingots that can be cast the mills must make the sizes in which they can compass the largest tonnage. In 1914 the plate mills made a great deal of light stuff which in the two succeeding years was shoved over to the jobbing mills, and the jobbing mills in their turn shoved the lighter of their gages up to the sheet mills. The sheet mills might here and there have shoved some lighter gage orders to the tin mills, but the tin plate consumers saw them first.

In the circumstances steel mills have become much more reserved in the matter of making delivery promises. Much business has been put through, the aggregate bookings easily exceeding the shipments, but the business has been chiefly of routine character, mills booking their regular customers for additional contract periods, without any definite promise of when deliveries would actually be undertaken.

The trend of steel prices has been upward, though not more markedly so than in the past. There was a very stiff advance in standard steel pipe, five points or about \$9 a net ton, the largest single advance on record in this material, but pipe had been disproportionately low. Even with the present advance the spread between billets per gross ton and pipe per net ton is substantially the same in dollars as when both commodities were at their lowest.

The American Sheet & Tin Plate Company has opened its books for third quarter in the case of jobbers and second half in the case of manufacturing consumers, at the following prices for Bessemer stock: Tin plate, \$7.50 per base box; blue annealed sheets, 5c. for 10 gage, with the old gage differentials, in recent months practically disregarded; black sheets, 5.50c. for 28 gage; galvanized sheets, 7c. for 28 gage, with increased differentials for lighter gages. For all products an extra of 25 cents per 100 lb. is charged for open-hearth, a rule that will probably be rigidly enforced to conserve the supply of open-hearth steel. Independents had expected higher prices for tin plates and galvanized sheets at least, and are not booking freely.

Transportation conditions have continued to improve, although not rapidly. Supplies of coke have become very nearly adequate, and production of pig iron has reached a rate of 40,000,000 tons a year, a shade above the average rate in 1916, but a rate which was exceeded by nearly 10 per cent in October and November. Pig iron has become scarcer and prices continue on the upward trend, frequently with advances of a dollar a ton overnight. Valley prices are \$35 for basic and \$40 for Bessemer.

Steel production has increased slightly, not having decreased during the traffic congestion as much as pig iron production. Steel shipments are better, and stocks accumulated at mills during the winter are being reduced. The chief concern now is as to whether the

opening of the season of lake navigation, with its heavy requirements of coal to be moved to Lake Erie ports, and iron ore to be moved therefrom, will cause a fresh railroad congestion. Reports are that an unusual number of locomotives are in repair shops and that motive power next month will be more efficient than ever.

Non-Ferrous Metal Market

Saturday, April 7.—There have been no radical price changes in any of the metals during the past two weeks, and the markets for the most part have been quiet. It is impossible to say at this time just what effect the entry of the United States into the world war will have on the metal markets, as it is not known just what quantities the Government will need or how the normal consuming trade will be affected. It is probable, however, that considerable copper and lead will be needed, but the Government has placed a ban on excessive war profits and will take over the management of any plant that holds out for a price considered excessive.

Copper.—The recent action of some of the large copper producers in selling 45,000,000 lb. of copper to the Government at one-half market price, or about 16 2/3 cents per pound, is significant and as many munition makers have completed their foreign contracts, and production has been increased to such a large extent, a drop in the price of copper can be looked for at any time. It is understood that the Government will need 90,000,000 lb. more of copper shortly, and doubtless will need far more than this when the munition and other plants begin large production. The *American Metal Market* has prepared an interesting table showing where our copper exports have been going:

	WHERE OUR COPPER EXPORTS ARE GOING		
	During February,	Jan. 1 to Feb. 28,	
(Short tons)	1917	1916	
United Kingdom	6,132	13,789	8,446
France	17,123	30,090	18,929
Germany	431	456	407
Holland	431	456	407
Belgium	431	456	407
Austria	431	456	407
Italy	4,217	7,944	10,498
Denmark	431	456	407
Norway and Sweden	431	456	407
Russia	1,500	3,250	800
China and Japan	431	456	407
Sundries	323	806	879
Total	30,392	57,350	44,311

At present electrolytic is quoted at 34.25 with lake at 34.50 for prompt shipment.

Tin.—The tin market has been quiet, with prices ruling fairly firm. A decline of about 1 1/2c. has taken place and spot Straits is now held at 54.75. Arrivals in March were 4804 tons, of which 1404 tons arrived at Pacific ports. It is likely that considerable more tin for tin cans will be needed during the next two years for shipping food products to Europe, provided the war goes on.

Spelter.—There is not much to be said about the spelter market. The spot New York quotation is 10.55c. The market has been featureless, but it may pick up if the brass manufacturers make shells on a large scale.

Lead.—The only change in the lead market has been a slight decline in the spot price of independents which is now 9.50c. The Trust price remains at 9.00c.

Other Metals.—Antimony has advanced 1 cent to 36.00. Spot is still scarce. Aluminium is quoted at 59.00-60.00c. for No. 1 virgin metal. Quicksilver is held at \$115.00 per flask, silver has advanced again and is now quoted at 73 3/4. On April 2 it was 74 1/2, having risen from 71 1/2 on March 26. Pure platinum is \$105.00 per ounce.

Chemical Market

The General Situation.—This review of the chemical situation is being written at the moment the tickers inform us the Declaration of War against the Imperial German Government is being placed before the President for his signature. Consequently to-day's markets for chemicals will mean little to-morrow. The great industry which American enterprise has developed during the past three years now faces its supreme test. Just what the government will do remains to be seen. Purchases will be made on an enormous scale, but abnormal profits will not be allowed. The margin of profit that will be allowed manufacturers is in doubt. The Entente governments have been allowing ten per cent margin, but it is stated that this percentage will be cut by Washington. Full authority has been given the Executive offices of the Government to take over and operate any plant that does not immediately agree to sell at the prices set by the Government. Already it is announced that one manufacturer who refused to sell at a set price has felt the influence of this new authority and has been notified that if he maintains his attitude he will find his plant in new operating hands shortly. Already the fertilizer industry has felt the influence of stirring current events. The Government has, according to reliable authority, commandeered the menhaden fishing vessels in the Chesapeake and ordered them to report to Norfolk. These swift light vessels of sturdy construction will presumably be armed and assume patrol duty similar to that of the English and Scotch trawlers.

Benzol.—The large producers now have the situation under better control than during any period of the past few months, and there is but little material now in outside hands. The independent producers are well sold up—in fact, most of them are not offering at all for delivery this year. The situation promises much from a sellers' viewpoint and indications seem to point to higher values.

Toluol.—There can now be but little doubt that large purchases of toluol will be made by the Government for T N T purposes and as a consequence the word "firmness" hardly describes the situation. During the fortnight the actual transactions reported were comparatively small. Firms controlling supplies are apparently content to sit back and await developments which seemingly are to be in their decided favor.

Phenol.—Despite continued strength in practically all products entering into munition manufacture, phenol rules easy. Competition has been too keen and production has apparently exceeded the supply. However, picric acid business is surely to appear soon, as this is at least one hope that it held out to makers.

Diphenylamine.—This stabilizer has been in urgent request, and the few producers report supplies well sold up with prices higher than have prevailed for some time.

Aniline Oil and "Salt."—A large producer of oil who is now consuming his own product has been in the market for an important tonnage during the interval with the result that prices have recorded substantial advances. Supplies are light and spot shipments are difficult to produce. "Salt" has advanced more in proportion than oil.

Monochlorobenzol.—Production has gradually increased and some makers are now offering stocks for immediate and future shipment. The tight situation recently noted has eased.

Toluidines.—There has been a very brisk demand for the *para* as a result of the explosion in one of the producing plants. Prices have advanced sharply. *Ortho* has also experienced more than an ordinary inquiry.

Paranitrotoluol.—A number of consumers have inquired for this material, but producers are well sold out and but little material is reaching outside hands.

Paranitrosodimethylaniline (base).—Rubber manufacturers have been much interested in this product and some sales have passed on the basis of \$3.50 for immediate shipment with contracts somewhat easier. Offers seem to be confined to but one source, and this factor states that regular supplies will be available from now on.

Heavy Chemicals.—The general position of products under this classification has been higher throughout the interval, and considerable business has transpired.

Caustic Soda and Soda Ash.—There has been important business transpiring in the alkalis during the interval and prices have steadily climbed. The export movement in caustic remains heavy and will probably continue so. Domestic consumers have been in the market in a large way as far forward as 1918, and a number of the leading producers are sold out. **Formaldehyde** has been in urgent inquiry for export to England. Spot stocks have been practically nil and buyers have taken up every offer made promptly. **Nitrite of soda**, in the absence of important supplies, has advanced 75 per cent in value, and both domestic producers are sold out. **Nitrate of soda** has been steady but the demand has not been urgent. **Bleaching powder** has been somewhat easier. **Acetate of lime** has taken a sharp advance due, it is stated, to the difficulty of getting coal supplies to the wood distillation plants which are situated at very remote points. **Acetone** has advanced sharply in sympathy. Probably the anticipated demand for this product had more to do with the advance in acetate of lime than the shortage of coal. In acids, **acetic** has again scored an advance. **Muriatic** is off and supplies are more than abundant. **Nitric acid** in contrast has been very firm and prices are again higher. There has been a very good demand for **sulphuric acid**, particularly the brimstone variety.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET APRIL 6, 1917

Acetic anhydride	lb.	1.75	—	2.00
Acetone, drums	lb.	.27	—	.27½
Acid, acetic, 28 per cent.	lb.	.04½	—	.05½
Acetic, 54 per cent.	lb.	.09	—	.09½
Acetic, glacial, 99½ per cent. carboys.	lb.	.27	—	.30
Boric, crystals	lb.	.11	—	.12
Citric, crystals	lb.	.76	—	.78
Hydrochloric, 18 deg.	lb.	.07½	—	.08½
Hydrochloric, 20 deg.	lb.	.01¾	—	.01½
Hydrochloric, C. P. conc. 22 deg.	lb.	.01½	—	.01¾
Hydrofluoric, 30 per cent. in barrels.	lb.	.04½	—	.05
Lactic, 44 per cent.	lb.	.10½	—	.12
Lactic, 22 per cent.	lb.	.05	—	.05½
Nitric, 36 deg.	lb.	.05½	—	.05½
Nitric, 42 deg.	lb.	.06½	—	.07
Oxalic, crystals	lb.	.46	—	.48
Phosphoric, 85 per cent.	lb.	.29	—	.31
Picric	lb.	.70	—	.75
Pyrogallol, resublimed	lb.	3.50	—	4.00
Sulphuric, 60 deg.	ton	19.00	—	20.00
Sulphuric, 66 deg.	ton	28.00	—	30.00
Sulphuric, oleum (Fuming), tank cars. ton		35.00	—	36.00
Tannic, U. S. P. bulk.	lb.	.45	—	.48
Tartaric, crystals	lb.	.84	—	.86
Alcohol, grain, 18 proof.	gal.	2.78	—	2.80
Alcohol, wood, 95 per cent.	gal.	1.00	—	1.02
Alcohol, denatured, 180 proof.	gal.	.70	—	.72
Alum, ammonia, lump.	lb.	.04	—	.04½
Alum, chrome ammonium	lb.	.18	—	.20
Alum, chrome potassium	lb.	.33	—	.40
Alum, chrome sodium	lb.	.22	—	.24
Alum, potash lump	lb.	.05½	—	.06
Aluminum, sulphate, technical	lb.	.02	—	.02
Aluminium sulphate, iron free.	lb.	.03½	—	.03½
Ammonia aqua, 26 deg. carboys.	lb.	.05½	—	.05½
Ammonium carbonate	lb.	.14	—	.15
Ammonium nitrate	lb.	.14½	—	.16
Ammonium, sulphate domestic	lb.	.05	—	.06
Amyl acetate	gal.	4.50	—	4.55
Arsenic, white	lb.	.15½	—	.16½
Arsenic, red	lb.	.07½	—	.08
Barium chloride	ton	90.00	—	95.00
Barium sulphate (Blanc Fixe) powder.	lb.	.11	—	.04½
Barium nitrate	lb.	.11½	—	.11½
Barium peroxide, basic 70 per cent.	lb.	.28	—	.30
Bleaching powder, 35 per cent chlorine, domestic, drums	lb.	.03½	—	.03½
Borax, crystals, sacks.	lb.	.07½	—	.08
Brimstone, crystals	ton	45.00	—	46.00
Bromine, technical	lb.	.90	—	1.00

Calcium, acetate, crude.....lb.	.03	—	.03½	Dichlor benzol.....lb.	.32	—	.34
Calcium, carbide.....ton	\$0.00	—	90.00	D nitro chlor benzol.....lb.	.46	—	.48
Calcium chloride, 70-75 per cent, fused, lump.....ton	27.50	—	30.00	Dimethylaniline.....lb.	.55	—	.58
Calcium peroxide.....lb.	1.70	—	1.75	Diphenylamine.....lb.	.90	—	1.00
Calcium phosphate.....lb.	.30	—	.33	H-sul.....lb.	1.60	—	1.60
Calcium sulphate.....lb.	.01½	—	.01½	Metaphenylenediamine.....lb.	1.45	—	1.60
Carbon bisulphide.....lb.	.04	—	.04½	Monochlorobenzol.....lb.	.35	—	.37
Carbon tetrachloride, drums.....lb.	.16	—	.17	Naphthalene, flake.....lb.	.09½	—	.10
Caustic potash, 82-92 per cent.....lb.	.76	—	.78	Naphthalene, lump.....lb.	1.25	—	2.00
Caustic potash, 70-75 per cent.....lb.	.64	—	.66	Nitro naphthalin.....lb.	.45	—	.60
Caustic soda, 46 per cent.....lb.	.043	—	.044	Ortho-amidophenol.....lb.	1.20	—	1.25
Chlorine, liquid.....lb.	100.00	—	100.00	Para-amidophenol base.....lb.	1.50	—	1.75
Copper.....100 lb.	1.05	—	1.15	Paranitraniline.....lb.	1.20	—	1.25
Copper carbonate.....lb.	.35	—	.38	Paraphenylenediamine.....lb.	3.50	—	3.75
Copper cyanide.....lb.	.75	—	.80	Para toluidine.....lb.	2.00	—	2.25
Copper sulphate.....lb.	.43½	—	.44	Phenol, U. S. P.....lb.	.43	—	.45
Cream of tartar, crystals.....lb.	3.50	—	4.00	Resorcin, technical.....lb.	16.00	—	17.00
Epsom salt, bags.....100 lb.	13½	—	14	Resorcin, pure.....lb.	.80	—	.85
Formaldehyde, 40 per cent.....lb.	.60	—	.70	Salicylic acid.....lb.	1.50	—	1.75
Glauber's salt.....lb.	.55½	—	.56	Sulphanilic acid.....lb.	.31	—	.32
Glycerine, bulk, C.P.....lb.	3.50	—	3.55	Tolidin.....lb.	3.00	—	3.00
Iodine, resublimed.....lb.	.02	—	.10	Toluidine-mixture.....lb.	.80	—	.85
Iron oxide.....lb.	.14	—	.16				
Lead acetate, white crystals.....lb.	.16½	—	.17				
Lead arsenate.....lb.	.08½	—	.10				
Lead nitrate.....lb.	1.03	—	1.04				
Litharge, American.....lb.	.60	—	.65				
Lithium carbonate.....ton	44.00	—	46.00				
Manganese dioxide.....lb.	.14	—	.15				
Magnesium carbonate, tech.....lb.	.11	—	.11				
Nickel, salt, single.....lb.	1.10	—	1.15				
Nickel, salt, double.....lb.	1.05	—	1.10				
Phosphorus.....lb.	.35	—	.36				
Phosphorus, yellow.....lb.	1.00	—	1.01				
Potassium bichromate.....lb.	1.00	—	1.01				
Potassium bromide granular.....lb.	80-85 per cent.....lb.	27.00	275.00				
Potassium carbonate calcined.....lb.	.58	—	.60				
Potassium chlorate, crystals.....lb.	1.60	—	1.65				
Potassium cyanide, 98-99 per cent.....lb.	2.80	—	2.95				
Potassium iodide.....lb.	390.00	—	400.00				
Potassium nitrate, 80-85 p.c. basis of 80 p.c. ton	.30	—	.31				
Potassium nitrate.....lb.	3.30	—	3.50				
Potassium permanganate.....lb.	2.50	—	2.75				
Potassium prussiate, red.....lb.	.90	—	.92				
Potassium prussiate, yellow.....lb.	.36	—	.37				
Potassium sulphate, 90-95 per cent.....lb.	.10	—	.11				
Rochelle salts.....lb.	.17½	—	.18				
Sal ammoniac, gray gran.....lb.	1.05	—	1.10				
Sal ammoniac, white gran.....lb.	.90	—	1.00				
Sal soda.....100 lb.	.70	—	.75				
Salt cake.....oz.	.45½	—	.47½				
Silver cyanide.....oz.	.036	—	.038				
Soda ash, 58 per cent, light, flat.....lb.	.09	—	.10				
Soda ash, 58 per cent, dense, flat.....lb.	6.50	—	7.00				
Sodium acetate.....lb.	1.90	—	2.00				
Sodium benzoate.....lb.	Nominal	—	Nominal				
Sodium bicarbonate, chem. pure.....100 lb.	.16	—	.18				
Sodium bicarbonate, English.....lb.	.04½	—	.04½				
Sodium bichromate.....lb.	.24	—	.26				
Sodium bisulphite, powdered.....lb.	1.00	—	1.05				
Sodium chlorate.....lb.	.11½	—	.12				
Sodium cyanide.....lb.	.01½	—	.02				
Sodium fluoride, commercial.....lb.	.05½	—	.05½				
Sodium hyposulphite.....lb.	.22	—	.24				
Sodium nitrate, refined.....lb.	.95	—	1.00				
Sodium nitrate.....lb.	.04½	—	.05				
Sodium peroxide.....lb.	.32	—	.33				
Sodium phosphate (tri.).....lb.	1.00	—	1.05				
Sodium prussiate, yellow.....lb.	2.00	—	2.25				
Sodium silicate, liquid, 40 deg.....100 lb.	.02½	—	.03				
Sodium silicate, liquid, 60 deg.....lb.	.03½	—	.03½				
Sodium sulphide, 30 per cent crystals.....lb.	.28	—	.30				
Sodium sulphide, 60 per cent fused.....lb.	.10½	—	.10½				
Sodium sulphite.....lb.	.11½	—	.12				
Strontium nitrate.....lb.	2.55	—	2.75				
Sulphur chloride, drums.....lb.	2.35	—	2.45				
Sulphur, dioxide, liquid, in cylinders.....lb.	45.00	—	45.00				
Sulphur, flowers, sublimed.....100 lb.	.14½	—	.15				
Sulphur, roll.....ton	.56	—	.57				
Sulphur, crude.....lb.	.24	—	.25				
Tin bichloride, 50 deg.....lb.	.16	—	.18				
Tin oxide.....lb.	.50	—	.50				
Zinc carbonate.....lb.	.18	—	.20				
Zinc chloride.....lb.	.12	—	.12				
Zinc cyanide.....lb.	.06½	—	.07				
Zinc dust.....lb.							
Zinc oxide, American process XX.....lb.							
Zinc sulphate.....lb.							

Petroleum Oils

Crude (at the Wells)

Pennsylvania.....bbl.	3.05	—	...
Corning, Ohio.....bbl.	2.38	—	...
Somerset, Ky.....bbl.	2.18	—	...
Wooster, Ohio.....bbl.	2.00	—	...
Indiana.....bbl.	1.73	—	...
Illinois.....bbl.	1.87	—	...
Oklahoma and Kansas.....bbl.	1.70	—	...
Caddo, La., light.....bbl.	1.90	—	...
Corsicana, Tex., light.....bbl.	1.70	—	...
California.....bbl.	.73	—	.82

Lubricants

Black, reduced, 29 gravity, 25-30 cold test, gal.	.13½	—	.14
Cylinder, light.....gal.	.21	—	.26
Cylinder, dark.....gal.	.18	—	.19
Extra cold test.....gal.	.26	—	.30
Paraffine, high viscosity.....gal.	.29½	—	.30
Paraffine, .905 sp. gr.....gal.	.21½	—	.22
Paraffine, .863 sp. gr.....gal.	.18½	—	.19

Flotation Oils

Pine oil, steam distilled.....gal.	.59	—	...
Pine oil, destructively distilled.....gal.	.47	—	...
Pine-tar oil.....gal.	.19	—	...
Pine-tar oil, double refined.....gal.	.30	—	...
Pine oil, light.....gal.	.37	—	...
Pine oil, heavy.....gal.	.26	—	...
Turpentine, crude.....gal.	.28	—	...
Pine tar, thin.....gal.	.18	—	...
Hardwood oil, f.o.b. Michigan.....gal.	.16	—	...
Cresote, coal tar, neutral.....gal.	.21	—	...
Cresote, coal tar, acid.....gal.	.21	—	...

Vegetable and Other Oils

China wood oil.....lb.	.14	—	.14½
Cottonseed oil, crude.....gal.	1.04	—	...
Linseed oil, raw, cars.....gal.	1.04	—	...
Peanut oil, crude.....gal.	1.00	—	...
Rosin oil, first run.....gal.	.38	—	...
Rosin oil, fourth run.....gal.	.67	—	...
Soya bean oil, Manchuria.....gal.	.13½	—	...
Turpentine, spirits.....gal.	.43	—	...

Miscellaneous Materials

Barytes, floated, white foreign.....ton	38.00	—	40.00
Barytes, floated, white, domestic.....ton	28.00	—	32.00
Beeswax, white pure.....lb.	.52	—	...
Carnauba wax, highest grade.....lb.	.51	—	...
Chalk, light, precipitated, English.....lb.	.03	—	...
Feldspar.....ton	8.00	—	12.00
Fuller's earth, powdered.....100 lb.	.80	—	1.05
Red lead, dry, carloads.....lb.	.10½	—	...
Rosin, 280 lb. bbl.....bbl.	6.00	—	...
Soapstone.....ton	10.00	—	12.50
Talc, American, white.....ton	16.00	—	13.00
White lead, dry.....lb.	.09½	—	...

Refractories, Etc.

(F.O.B. Works)

Chrome brick.....net ton	Nominal	—	...
Chrome cement, Grecian.....net ton	60.00	—	...
Clay brick, 1st quality fireclay.....net ton	45.00	—	...
Clay brick, second quality.....per 1000	30.00	—	...
Magnesite, Grecian, dead burned.....net ton	90.00	—	...
Magnesia brick, Grecian, 9x4½x2½.....net ton	140.00	—	...
Silica brick, American, white.....per 1000	45.00	—	...

Ferroalloys

Ferro-carbon-titanium, carloads.....lb.	.12½	—	...
Ferrochromium.....net ton	Nominal	—	...
Ferromanganese, domestic, delivered.....ton	300.00	—	325.00
Ferromanganese, English.....ton	185.00	—	...
Ferromolybdenum, per lb. of Mo.....lb.	4.00	—	...
Ferrosilicon, 50 per cent carloads del. Pitts-burgh.....ton	200.00	—	250.00
Ferrosilicon, 50 per cent, contract.....ton	100.00	—	...
Ferrotungsten, 75-85 per cent, f.o.b. Pitts-burgh.....lb.	1.95	—	...
Ferrovanadium f.o.b. works.....lb.	2.75	—	3.00

Intermediates, Etc.

Alpha naphthylamine.....lb.	1.10	—	1.25
Aniline oil.....lb.	.28	—	.28½
Aniline salts.....lb.	.33	—	.35
Anthracene, 80 per cent.....lb.	.10	—	...
Benzaldehyde.....lb.	.00	—	...
Benzidine, base.....lb.	1.75	—	1.80
Benzidine, sulphate.....lb.	1.50	—	1.55
Benzoic acid.....lb.	7.00	—	7.25
Beta naphthol, sublimed.....lb.	.80	—	.85

Coal Tar Products (Crude)

Benzol, pure, water white.....gal.	.58	—	.60
Benzol, 90 per cent.....gal.	.58	—	.58
Toluol, pure, water white.....gal.	1.75	—	1.90
Xyol, pure, water white.....gal.	.55	—	1.00
Solvent naphtha, water white.....gal.	.18	—	.20
Solvent naphtha, crude heavy.....gal.	.14	—	.16
Cresote oil, 5 per cent.....gal.	.28	—	.30
Dip oil, 20 per cent.....ton	8.00	—	20.00
Pitch, various grade.....ton	.30	—	.35
Carbolic acid, crude, 95-97 per cent.....lb.	.23	—	.25
Carbolic acid, crude, 50 per cent.....lb.	.48	—	.50
Carbolic acid, crude, 25 per cent.....lb.	.20	—	.21
Cresol, U. S. P.....lb.			

INDUSTRIAL

Financial, Construction and Manufacturers' News

Financial

New Companies

Air Reduction Co. has been incorporated in California with a capital of \$100,000 to produce and deal in oxygen and other gases. The main office is at 120 Broadway, New York.

The Alpha Chemical Works, Inc., has been chartered to manufacture and deal in drugs, chemicals, etc., with \$1,000,000 capital, by A. W. Britton, S. B. Howard and L. H. Gunter, all of New York City.

American Colors, Inc., Philadelphia, Pa., has been incorporated with a capital of \$200,000 to manufacture and deal in colors, dyestuffs and chemicals.

Ampco Rolling Mills Corp., Delaware, has been incorporated with a capital of \$1,000,000 to buy, lease and develop and control steel and bronze metal rolling mills. The incorporators are Edgar E. Warner, Peter Weber, A. E. Martin, Milwaukee, Wisconsin.

Associated Rolling Mills, Ltd., New York, has been incorporated with a capital of \$50,000 to business in metal products, manufacturing, engineering, contracting. The incorporators are W. F. Keers, E. M. Higgins, H. J. Bally, 32 Liberty Street.

Blandon Rolling Mills, Inc., Harrisburg, Pa., has been incorporated with a capital of \$150,000. Incorporator Samuel R. Seyfert.

O. A. Brown Co., Inc., New York, has been incorporated with a capital of \$100,000 to deal in essential oils, materials, edible, synthetic oils, dyestuffs, chemicals, perfumes, soaps. The incorporators are E. C. O. Thomas, A. O. O'Connell, O. A. Brown, 344 West 72d Street.

Carnation Copper Co., Delaware, has been incorporated with a capital of \$1,500,000 to produce and deal in refined sulphur and other minerals. The incorporators are Herbert E. Latter, Norman P. Coffin, Clement M. Egnor, Wilmington, Del.

Castle Valley Sulphur Co., Charleston, W. Va., has been incorporated with a capital of \$25,000 to deal in and refine sulphur and other minerals. The incorporators are Chas. H. Henning, Lee Ott and A. B. Bright.

Chemical Manufacturing Company, Inc., Brooklyn, New York, has been incorporated with a capital of \$50,000. The incorporators are James J. Nevin, Mollie Nevin and Mendel Nevin of Brooklyn.

Corporation for Chemical Industry, Philadelphia, Pa., has been incorporated with a capital of \$100,000 to manufacture and sell dyers' oils and coal tar. The incorporators are F. R. Hansell, Philadelphia; Martin and Seymour, Camden, N. J.

Eastern Talc Co., Portland, Me., has been incorporated with a capital of \$750,000 to produce and prepare, manufacture and deal in talc and similar substances.

Firman Potash Company, Los Angeles, Cal., has been incorporated with a capital of \$100,000. The incorporators are Dr. John M. Cleaver, Arthur H. Firman, Chas. F. Tanner, A. O. Hoyt, Harry J. Mumma.

The General Silica Company, chartered under the laws of Delaware by Paul Hyde, C. I. Shaffer and John W. Pitt, all of Chicago, Ill., to produce, grind and mine for sell and silica, with \$1,000,000 capital.

A. L. Goesslin Corporation, New York, has been incorporated with a capital of \$50,000. Chemicals, dyestuffs, food products, canned goods. The incorporators are J. E. Roesser, J. B. Meyer, A. L. Goesslin, 20 West 59th Street, N. Y. C.

Great American Chemical Products Co., Inc., Dover, Del., has been incorporated with a capital of \$10,000,000 to carry on a general business of chemist and druggists, etc. The incorporators are John A. Latter, Norman P. Coffin, Clement M. Egnor, Wilmington, Del.

The Hamilton Furnace Co., Columbus, Ohio, has been incorporated with a capital of \$400,000. The incorporators are John A. Savage, J. E. McCloskey, A. E. Gillespie, F. J. Lashley and J. C. Alexandriner.

Hatch Glass Sand Corp., Buffalo, N. Y., has been incorporated with a capital of

\$25,000 to deal in sand, gravel, stone. The incorporators are C. T. Hurley, V. E. O'Grady, C. C. Hatch, 62 Imeson Street, Buffalo, N. Y.

Hy-Carbo Steel Co., Lowell, Mass., has been incorporated with a capital of \$20,000. The incorporators are Chas. H. Bagshaw, 79 Wedge Street, Lowell; I. E. Higgins and M. C. Bagshaw.

The Indianapolis Foundry Company, Indianapolis, Ind., has been reorganized with a capital of \$175,000. The new name of the company is the Indianapolis Castings Company. The company operates a plant near South Harding and West Washington Streets. The incorporators are Frank E. Lewis, John Wallace and Charles O. Roemer. Mr. Lewis has been president of the Indianapolis Foundry Company for a number of years. He will continue in the management of the new company. Castings and similar products are manufactured at the plant. The plant has been in operation in Indianapolis for twenty-five years.

The Jackson County Oil Co., has been organized in Berea, Ky., with \$4,000 capital by D. H. Welch, J. C. Gilbert and W. M. Farmer.

James & Breckler, Louisville, Ky., has been incorporated with a capital of \$6,000 to manufacture chemicals. The incorporators are W. E. James, New Albany; James Breckler, Louisville; E. Danenbaum, Des Moines; Thomas Edwards, Clarksville.

Laclede Chemical Company, St. Louis, Mo., has been incorporated with a capital of \$100,000 to manufacture coal-tar products. The incorporators are C. T. Swarts, E. C. Edmiston, T. H. Budke, J. R. Glasco.

The Latent Metal Company, Newark, N. J., has been incorporated with a capital of \$35,000 to manufacture chemicals for the treating of iron, steel, copper and other metals. The incorporators are George C. Helmick, William H. Perrine and Ernest H. Fougner, Newark.

Leather Processes, Inc., Manhattan, has been incorporated with a capital of \$7,500 to manufacture articles used in tanning and production of leather goods. The incorporators are E. J. Wessels, F. R. Pentlauge and E. C. Fischer, Newark, N. J.

Majestic Mills Paper Co., New York City, has been incorporated with a capital of \$4,500 to manufacture paper, cardboard, twine, etc. The incorporators are A. Warshaw, William George Green, S. A. Giacobbe.

Medina Fullers Earth Company, San Antonio, Tex., capital \$100,000; to mine fullers earth and kaolin, prepare for market and manufacture into other articles. O. T. Gregory, E. D. Henry and L. R. Parker.

Melrose Chemical Co., Newark, N. J., has been incorporated with a capital of \$2,000 to deal in chemicals. The incorporators are John H. Fertie, Montclair; Alexander A. Bergner, Newark; Louis Pivarnick, New York.

H. A. Metz Laboratories, Inc., New York, has been incorporated with a capital of \$10,000 to deal in copper, lead, zinc, etc. The incorporators are G. Fuchlein, G. P. and H. A. Metz, 122 Hudson Street.

Millard Copper Company, New York, has been incorporated with a capital of \$50,000 to deal in copper, lead, zinc, etc. The incorporators are A. W. Britton, S. B. Howard and L. H. Gunther, all of New York.

The Millasir Mining Corporation, New York City, has been incorporated with \$100,000 capital, by R. H. Rixon, Peekskill; H. W. Harrison, M. Olyphant, 66 Broadway, New York. The company is authorized to conduct a mining, smelting and refining business.

Mineoil Company, New York, has been incorporated with a capital of \$10,000. Business: mining, smelting. The incorporators are A. M. and W. A. Dvorkind, and Dr. A. H. Malaney, Atlanta, Ga.

The Mo-Ark Oxygen Company, St. Louis, Mo., has been incorporated with \$25,000 capital to manufacture oxygen. By Rudolph Best, Louis Rosen and B. T. Clifford.

Monarch Oil & Chemical Company, Philadelphia, Pa., has been incorporated with a capital of \$60,000 to deal in oil and other

products. The incorporators are Frank E. Lamb, Reuben Dierweicht, and George W. Lively, all of Philadelphia.

Natura Chemical Corporation, Buffalo, N. Y., has been incorporated with a capital of \$100,000 to deal in chemicals and drugs. The incorporators are R. M. Weiss, R. C. and F. E. Holland, 140 Goulding Avenue, Buffalo, N. Y.

National Carbon Coated Paper Company, Cleveland, Ohio, has been incorporated with a capital of \$300,000. Incorporator, C. L. Spence.

New York and Pennsylvania Gasoline Corp., Buffalo, N. Y., has been incorporated with a capital of \$250,000 to buy lands and produce oil. The incorporators are C. B. and L. Runyon, J. P. Hanlon, 62 Irving Place, Buffalo.

Oklahoma-Kansas Oil & Mining Company, Wilmington, Del., has been incorporated with a capital of \$2,000,000 to acquire oil lands and develop same.

Oklahoma-Kentucky Oil Company, Frankfort, Ky., has been incorporated with a capital of \$25,000,000. The incorporators are George E. Williams, Irvine; W. A. Aule, J. D. Lacey, F. O. Dings, H. H. Wallace and Roy M. Johnson, Ardmore; Ed. Dunlap, Ardmore; B. V. Hole, Burdette, Okla.; W. J. Bonner, Oklahoma City; C. S. Sipple, London, Ky.

The Panoleum Corporation, New York, has been incorporated with a capital of \$10,000 to deal in metals, oils, paper, rags, waste, etc. The incorporators are A. G. Howard, H. J. Boneberg and George K. Mantz, all of Buffalo.

Paraloid Works, Inc., Yonkers, N. Y., has been incorporated with a capital of \$80,000 to deal in celluloid, imitation ivory, glass, amber, ivory, rubber, linen. The incorporators are S. L. Jackson, P. C. Pitcher, H. H. Schneider, Hastings-on-Hudson.

Penn Keystone Company, New York City, and Penn Keystone Graphite & Paint Company have been consolidated under the name of Penn Keystone Company of New York City.

The Petrol Refining Process, Inc., has been incorporated with a capital of \$100,000 to deal in mining, treating coal and oils. The incorporators are L. Pfeiffer and W. P. Enghelman, 265 Oakland Avenue, West New Brighton.

The Pfanzstiel Company, Millbrook, N. Y., has been incorporated with a capital of \$405,000 to manufacture metals of all kinds and products. The incorporators are Jerome M. Frank, A. L. Schwartz and H. S. Gould.

Pittsburgh Compound Company, Pittsburgh, Pa., has been incorporated with a capital of \$10,000 to deal in oils, greases, etc. The incorporators are William McK. Scott, S. M. Long, Joseph W. Henderson, Pittsburgh.

Pollock Ink Works, Inc., Buffalo, N. Y., has been incorporated with a capital of \$25,000 to deal in ink, dyes, varnishes, coloring materials. The incorporators are C. A. Laawahl, H. and C. M. Kart, Buffalo.

Red-Lock Products Co., Dover, Cal., has been incorporated with a capital of \$1,000,000 to manufacture and deal in drugs, etc. The incorporators are Charles H. Jones, George W. Morgan, W. I. M. Lofland, all of Dover.

Rochester Essential Products Co., Inc., Rochester, N. Y., has been incorporated with a capital of \$50,000 to deal in poultry, birds and animal foods, remedies, merchandise, drugs, stationery. The incorporators are G. Lee, E. Clarke, W. A. Matson, 15 Rochester Savings Bank, Rochester, New York.

The Royal Improvement Co., has been organized at Covington, Ky., by Emery N. Davis, Cacer Young, T. J. Kirkpatrick and others with \$500,000.

The Roxana Petroleum Company, Richmond, Va., has been incorporated with a capital of \$60,000,000 to engage in general oil development enterprises. The incorporators are Thomas B. Gay of Richmond, Va., president; B. E. Brice, Tulsa, vice-president; W. L. McGrady of Bayonne, N. J., secretary and treasurer.

The Sanitary Coating Co., Wilmington, Del., has been incorporated with a capital of \$200,000 to manufacture all kinds of paper and paper substitutes.

Sanolene Company, Inc., Rochester, N. Y., has been incorporated with a capital of \$14,000 to deal in soap, dye, disinfectants and chemicals. The incorporators are J. A. Hotchkiss, S. S. Macdill and G. W. Heath, 249 Elm Street, Rochester.

Simley Steel Company, New York, has been incorporated with a capital of \$5,000 to manufacture steel and manganese. The

incorporators are J. F. O'Neill, Leo R. Healy and D. D. Vincent, Manhattan.

Sunbeam Chemical Company, Chicago, Ill., has been incorporated with a capital of \$25,000 to manufacture and deal in soaps, dyes and chemicals.

The Sunset Oil Company, Cheyenne, Wyo., has been incorporated with a capital of \$5,000,000. The incorporators are A. A. Spaulgh, W. P. Spaulgh of Manville, and J. A. Manorgan and Thomas H. Blair of Colorado.

Suor Oil Products Corp., Buffalo, N. Y., has been incorporated with a capital of \$200,000 to manufacture petroleum products. The incorporators are C. T. Harley, V. E. O'Grady, J. F. Suor, 1276 Main Street, Buffalo, N. Y.

Sutphin Paper Co., New York City, has been incorporated with a capital of \$50,000, to manufacture paper and wood pulp. The incorporators are Henry T. Sutphin, Joseph H. Sutphin, John T. Leal.

Tanner Plant and Oil Co., Inc., Richmond, Va., has been incorporated. The incorporators are William E. Tanner, E. M. Long, both of Richmond.

Torchwood Equipment Company, Wilmington, Del., has been incorporated with a capital of \$100,000 to manufacture all kinds of metal weldings, brazing, etc. The incorporators are M. B. Gatchell, L. A. Irwin, Harry W. Davis, all of Wilmington, Del.

Tubular Steel Drug Corporation, Manhattan, has been incorporated with a capital of \$100,000 to conduct business of mining, smelting, rolling, mill, stamping, etc. The incorporators are W. J. Shilliday, W. E. Perry, A. E. Poye, 2 Rector Street, New York City.

The Tulsa Paper Company, Tulsa, Okla., has been incorporated with a capital of \$50,000. The incorporators are B. Hirschland, Oklahoma City, J. Martin, Tulsa, Okla., and A. N. Jochem, Oklahoma City, Okla.

The Union Wood Flour Company, Hudson Falls, N. Y., has been incorporated with a capital of \$30,000 to manufacture pulp and paper. The incorporators are J. J. Cunningham, P. J. Reilly and E. C. Rogers of Hudson Falls.

United Dyes Corporation, 175 Smith Street, Perth Amboy, N. J., has been incorporated with a capital of \$500,000 to manufacture dyes, chemicals, etc.

The United Gas Products Company, Wilmington, Del., has been incorporated with a capital of \$200,000 to manufacture and deal in oxygen, hydrogen and other gases.

United States Fluorspar & Lead Company, Wilmington, Del., has been incorporated with a capital of \$300,000.

Vacuum Gasoline Company, Lawrenceville, Ill., has been incorporated with a capital of \$100,000 to produce and manufacture gas, gasoline and petroleum.

The Vendette-Alberta Oil Company, Providence, R. I., has been incorporated with a capital of \$100,000; 10,000 shares of \$10 each. The incorporators are Edmond Vandette and Nicholas G. Votolato of Providence; Lester T. Murphy, West Warwick.

Vermont Products Co., Uteia, N. Y., has been incorporated with a capital of \$50,000 to deal in lumber lands, wood products, paper, chemicals, cements, paints, oils, scientific apparatus. The incorporators are H. Ferris, D. F. Strobel, J. M. Richards, Herkimer.

The Webb Chemical Co., St. Louis, Mo., has been incorporated with a capital of \$50,000 to deal in and manufacture toilet preparations, poultry remedies and similar articles. The incorporators are A. T. Webb, W. O. Baker and H. E. Labe.

The Wichita Independent Consolidated Companies, Dover, Del., has been incorporated with a capital of \$25,000,000 to produce and sell crude petroleum and products and acquire mineral lands and levels. The incorporators are H. J. Buser, A. F. Buser, P. A. Beach, C. J. Carney and W. D. Jochems of Wichita, Kan.

Financial Reports, Capital Increases, Etc.

Directors of the Sharon Steel Hoe Company met recently in the principal offices in Sharon, Pa., for the purpose of discussing details of the absorption of the Youngstown Iron & Steel Company. Plans for the formation of the new holding company were also considered. The meeting was called by Mr. Severn P. Ker, president. Plans are being formulated to float a bond of \$1,000,000. It is stated that financial details. Shareholders of the local company given the right to subscribe in stock of the new concern up

to par value of their holdings, have taken about \$1,250,000 stock.

The J. Y. J. Corporation of Pennington, N. J., manufacturer of sulphur dyes, has changed its title to the Westover Chemical Company. In addition to manufacturing sulphur colors, this company will make other colors and chemicals related to the color trade.

The Chemical Catalogue Company, Inc., has increased its capital from \$25,000 to \$50,000.

The Ferro Machine and Foundry Company, Cleveland, Ohio, increase from \$1,000,000 to \$1,750,000.

Lake Erie Smelting & Refining Co., Cleveland, Ohio, increase from \$50,000 to \$80,000.

The National Drawn Steel Company, East Liverpool, Ohio, increase from \$150,000 to \$200,000.

Royal Silver Manufacturing Co., Inc., Norfolk, Va. increase from \$25,000 to \$50,000.

Schlesinger Radium Company, Inc., New York City, increase from \$100,000 to \$150,000.

Slocum, Avram & Slocum Laboratories, Inc., New York City, increase from \$100,000 to \$200,000.

The Spencer Metal Products Co., Spencer, Ohio, increase from \$25,000 to \$50,000.

The Commonwealth Acid Phosphate Corporation, New York City, has changed its name to the Commonwealth Chemical Company.

The Libbey Glass Co., Toledo, Ohio, has increased its capital from \$1,000,000 to \$2,500,000. Expansion in the Sandusky and Erie plants in the purchase of new machinery accounts for this increase, according to William F. Donovan, assistant treasurer. Several new lines of glass making machinery will be manufactured both in the local and in the Sandusky plants. The improvements will take place within the next two years.

The Northwestern Chemical Company, Marietta, Ohio, has increased its capital from \$100,000 to \$150,000. The increase in capital stock was made necessary by the rapidly growing business of the company. The new factory which was built last summer in Norwood was considered, when built, to be large enough to take care of any expansion in business, but will not handle the present business. Work will be started upon two new buildings as soon as the weather permits.

The Tidewater Oil Company, New Jersey, has increased its capital from \$30,000,000 to \$40,000,000.

The Smet-Solvay Company, Milton Avenue, Solvay, N. Y., manufacturer of coke and by-products, has increased its capital from \$10,000,000 to \$20,000,000 for expansion.

HARRISON BROS. & COMPANY, INC., Philadelphia, Pa., has been sold to the E. J. du Pont de Nemours & Company. The sale was approved at a recent meeting of the stockholders. The companies are both very old ones, the Harrison company starting in 1793 and the du Pont company in 1802. The paint and varnish business of the Harrison company will be continued and expanded. The Harrison plant is on Gray's Ferry Road, on the Schuylkill River. It covers forty acres. The company also controls the Mantua Chemical Company of Fairbury, N. J., and owns a plant at Camden, N. J. The price paid by the du Ponts was \$5,700,000. The company will have a new name, Harrisons, Inc., of which the directors are Lamont du Pont, Dr. Charles L. Reese and Charles A. Meade of the du Pont company; A. R. Glaney and William Richter of the Harrison company.

THE BARRETT COMPANY, 17 Battery Place, New York, held a special meeting of stockholders Friday, March 16, in Jersey City, and voted to increase the authorized capital stock from \$20,000,000 to \$37,500,000.

The company reports for the twelve months ended December 31 last gross income from all sources \$9,547,604, an increase of \$2,894,965. The net increased \$2,044,192.

William Hamlin Childs, president of the company, pointed out to the stockholders that in addition to the usual 7 per cent cash dividends on the common stock there were extra dividends of 7 per cent and of 10 per cent disbursed in July and in December last, respectively. The total sales of the Barrett Company, he said (aside from its commission business), aggregated \$27,318,797 last year, as compared with \$15,883,910 in 1915. He stated that in all departments, both technical and financial, the company is in better condition than ever before in its history.

The report for the year ended December 31 last is as follows:

	1916.	Changes.
Gross income...	\$9,547,604	Inc. \$2,894,965
Total expenses...	4,382,318	Inc. 850,863
Net income...	\$5,165,286	Inc. \$2,044,192
Interest	138,657	Dec. 52,563
Net profit....	\$5,026,629	Inc. \$2,096,665
Reserve, etc.	758,771	Inc. 331,043
Net final profit applicable to Barrett Co.	4,247,858	Inc. 1,765,621
Pref'd dividend.	333,249	Inc. 158,249
Bal. for com.	\$3,914,603	Inc. 1,607,372
Common div'd.	2,817,325	Inc. 1,517,393
Surplus	\$1,097,283	Inc. \$89,979

Net earnings after interest and preferred dividend amounted to \$4,664,609 or 41.29 per cent, as against \$2,624,237 or 24.55 per cent in the preceding year, based on the \$11,298,200 of common stock.

Construction and Operation

Alabama

BIRMINGHAM.—The Sloss-Sheffield Steel and Iron Company has made some changes in its management and is expected to erect a by-product coke plant. The company is a large pig iron producer and the erection of a large steel plant is also considered. An inventory is at present being made under the direction of Major J. M. Sewell. Mr. Waddell Catchings was recently elected president. During 1916 the Sloss Company started a great increase in its pig iron production was 71,000 tons greater than any other previous year. There were 300,000 tons more coal produced than in any year of the company's history, and 400,000 tons more than in 1915. The coal output was 510,000. The total income of the company was \$2,219,532, as compared with \$908,075 the year before, and the surplus was \$1,521,875, as compared with \$170,638. The profit and loss surplus was \$5,049,866 at the end of 1916.

California

OAKLAND.—The Hammer Bray Company will erect a new building with a foundry for making castings for stoves.

OROVILLE.—U. S. Exploration Co. plans erecting large mill and power plant at its mine in Granite Basin this summer.

Connecticut

STAMFORD.—The Connecticut Smelting and Foundries Company has completed a new smelter at Springfield. The apparatus and machinery, however, has not been installed.

Delaware

WILMINGTON.—The plant of the Mineral Products Manufacturing Company has been sold to Taber-Davidson Company, which will manufacture fibre products. The material is not a competitor of the vulcanized fibre, but a supplementary product. The property purchased consists of three and one-half acres containing a large building. Additions have been started and construction will go ahead promptly. The officers of the Taber-Davidson Company are H. P. Taber of the Taber Laboratories Corporation, president; Chas. A. Davidson, vice-president; Chas. A. Rudolph, treasurer; Chas. E. McCarroll secretary. The material is called die-cast fibre and is claimed to require no machinery. The material is used for insulation and other purposes.

Florida

TAMPA.—The Export Railway Company is planning the establishment of a phosphate mining plant on Hillsborough Bay, which will cost \$1,000,000. The plant will be complete in one year. The American Mining and Phosphate Company, a subsidiary, will develop a tract of 275 acres near Bloomingdale. The total capacity of the phosphate plant will be 200,000 tons a year.

Illinois

PEORIA.—The new open hearth steel plant of the Keystone Steel and Wire Company is nearing completion. The new plant will require more than five hundred men in addition to what are employed at the old works. The new plant will be modern in every respect.

Louisiana

NEW ORLEANS.—The Louisiana Fibre Board Company is planning to enlarge its plant in order to double the capacity. The Bogalusa Paper Company has ordered \$1,500,000 worth of machinery, which will be installed during the next three months. The two plants will then represent an investment of \$4,000,000 at Bogalusa. Eventually 400 men will be employed at this plant. Mr. G. H. Wood is president of the Tivier Raisin Paper Company, vice-president of the Louisiana Fibre Board Company of Bogalusa.

Maryland

BALTIMORE.—National Enameling & Stamping Co., 1901 Light Street, has plans prepared for erecting 4-story building of brick and steel on Light and Well Streets; cost about \$60,000.

BALTIMORE.—The Standard Guano Company will erect an acid phosphate plant on Curtis Bay, which will turn out 1000 tons of acid phosphate per day. It is reported that the company recently received an order for 2,000,000 tons of the material from the Dutch Government. The company has already a plant in operation and is manufacturing glue and greases. Another plant is planned and will have an output of 100,000 tons of grease per month. This plant will cost \$100,000.

Massachusetts

PITTSFIELD.—A large tract of woodland has been bought by the Canaan, Conn., wood alcohol works; the land is in pine and Washington and contains many acres.

Michigan

MUSKEGON.—The Lakey Foundry & Machine Co., recently purchased by Detroit and Moline capitalists and has increased its capital from \$70,000 to \$100,000. A new foundry will cost \$200,000.

Missouri

ST. LOUIS.—The Fulton Iron Works has been constructing a large force works in the Wellston district. The company is a large manufacturer of sugar mills. It also has the rights to manufacture Diesel engines.

ST. LOUIS.—A large company is contemplating the location of a copper smelter in St. Louis. St. Louis is considered as the only interior center at which the smelter could be located. The industrial department of a St. Louis Railroad is negotiating with this company.

Montana

BAKER.—The Gas Products Company of Minneapolis, Minn., will erect a plant for the manufacture of carbon black. About 125 men will be employed. Baker has been selected as the site for the plant because of the immense quantities of natural gas that exist here.

Nevada

CARSON CITY.—A bill has been introduced at the assembly providing for a State smelter to cost \$500,000. The smelter will be known as the Nevada State Smelter and will treat ores when the owners are not able to build their own smelters.

New Jersey

ELIZABETH.—The Singer Manufacturing Company will erect an addition to its foundry which will cost \$50,000.

LINDEN.—Reported Grasselli Chemical Co. plans erecting 200 x 40-ft. addition to present plant, to cost \$63,000.

NEWARK.—The Newark Wire Cloth Company, Inc., 244 Verona Avenue, Newark, N. J., has purchased property at 848-54 Mt. Prospect Avenue, for a new 4-story plant, 100 x 125 ft., estimated to cost \$50,000. John C. Campbell is president.

NEWARK.—The North American Copper Co., with offices at 52 Vanderbilt Avenue, New York City, has purchased land on the Newark meadows for the erection of a copper refinery. Construction work will not be started for several months.

PASSAIC.—The Manhattan Rubber Mfg. Company, Willet Street, Passaic, N. J., manufacturer of mechanical rubber goods, has filed plans for an addition to cost \$140,000.

New York

BROOKLYN.—The Meurer Steel Barrel Company, 567 Flushing Avenue, Brooklyn, N. Y., has increased its capital stock from \$350,000 to \$650,000 to provide funds for its increased capacity. The company recently put up two new buildings at its plant at Long Island City. Jacob Meurer is president.

FORT EDWARD.—The International Paper Company has commenced the erection of an acid plant to cost \$70,000.

SYRACUSE.—The Halcomb Steel Company will erect two additional furnaces at its plant here. The company has three electric furnaces in operation and this will make five altogether.

North Carolina

WATERBEE.—The Southern Power Company has awarded a contract to the Hardyway Contracting Company for the construction of a hydroelectric plant, which will represent an investment of about \$60,000. The contract was awarded by J. H. Duke for the Southern Power Company.

Ohio

CLEVELAND.—C. F. Mitchell & Son, Cedar Avenue and East 65th Street, makers of automobile sheet metal parts, contemplate erecting plant on East 131st Street; cost \$250,000.

FINDLAY.—The Findlay Steel Castings Company, a \$200,000 corporation, has purchased the old plant of the Grant Motor Carriage Co., recently located to Cleveland. The Findlay company will manufacture steel castings by electricity. The officers of the company are E. J. Edwards of Detroit, Mich., president, E. T. Pelton of Milwaukee, secretary, and Dr. C. H. Gage of Oakland, Cal., chemist.

KENTON.—The Champion Iron Company has been reorganized and plans have been made to finance the concern on a much larger scale. Important factory improvements will be made.

LIMA.—The Ohio Steel Foundry Company has awarded a new contract for the construction of a new machine shop to cost \$25,000. The company originally purchased a plant at Bucyrus and is also negotiating for a foundry at Springfield.

MOUNT GILEAD.—Detailed plans are now completed and in the course of execution, rebuilding the burned portion of the plant of The Hydraulic Press Mfg. Co. on its present site in Mount Gilead, Ohio. The plans also include the erection of two additional buildings, which will give more adequate manufacturing facilities. The plans cover the erection of four complete new buildings, consisting of a machine shop, a three story stock room, a new power plant and a structural and forge shop. The machine shop and stock room are replacements on a much larger scale of the portion of the plant recently destroyed by fire. Considerable equipment has been purchased and much more will be needed. The new machine shop will be 200 ft. long and 100 ft. wide and of fireproof construction. An electric traveling crane of 20 tons' capacity will be located in the center portion of the building and operate on a track running the entire length of the structure. This equipment will give adequate facilities for lifting and moving heavy castings of hydraulic machinery in the course of their manufacture.

Two smaller electric cranes of three tons capacity will be operated in each side wing of the building. In addition to the new crane equipment considerable other new machinery will be installed, consisting in part of brookline mills, miller machines, lathes, planers, etc. A new power plant will also be erected. This building will occupy a space of 42 ft. x 60 ft. It will be of fireproof construction. For further power the power a new 300-hp. Corliss engine will be installed. A 300-hp. water tube boiler, equipped with an automatic stoker will be operated by the new power plant equipment. The present power plant of the company will remain intact so that it can be used in case of emergency or as an auxiliary. Plans for erecting a structural steel shop, the company plans to erect a structural and forge shop immediately east of the present erecting shop. This building will be 60 ft. x 60 ft. A adequately equipped forge shop will be located in this building. Cut-off saws and other equipment will be installed in this new building. Ground is being broken for the new power plant. Work on all buildings will begin immediately and vigorously pushed to completion. It is planned to have the new buildings in full operation by July 1.

STEUBENVILLE.—The Labell Iron Works has under consideration the erecting of a \$5,000,000 steel mill just south of the

company's coke ovens in Brooke County. The report is unconfirmed as yet. Stockholders of the company held a meeting about the middle of March, at which President K. C. Kirk reported that the earnings of the company for the calendar year 1916 were close to \$6,000,000. The resolution offering the plant to the government in time of war was unanimously adopted. The company produced 11,988 net tons of coal from the beehive ovens during the year. The progress made in the construction of the 94 by-product ovens of 12½ tons capacity was considerable. It was hoped that this plant would be in operation by the beginning of the fourth quarter. It is now expected that they will be in operation very shortly.

Oklahoma

TULSA.—The Prest-O-Lite Company is remodeling the large building formerly occupied by the Neodesha Glass Company, and will install machinery for the manufacture of dissolved acetylene. Mr. A. F. Brennan will have charge of this factory.

Pennsylvania

CHESTER.—The Chester Paper Company will install the largest paper machine in the country. It is now being shipped on 33 cars, and when assembled will turn out paper 147 in. wide.

CHESTER.—The Scott Paper Company of Philadelphia is planning the removal of its entire plant to the site of the old Smith factory here. Proposed extensions and additions are planned which cost \$500,000.

EASTON.—Dr. Frank Bryon Morse, head of the Radium Chemical Company of New York, was guest at a luncheon at the Rotary Club here on March 5. The Radium company has decided to locate a plant in Easton for the manufacture of radium. The company has already secured contracts for this material in Europe, and has a plant at Boston.

MARCUS HOOK.—The General Chemical Company, 25 Broad Street, New York, is making rapid progress in the erection of its new plant at Marcus Hook, Pa. The buildings for the most part are three and four-story structures, averaging from 100 x 200 to 600 ft. in size. It is said that four or five of the new buildings will be used by the Baker Adamson Company, a subsidiary.

NEW CASTLE.—The Pennsylvania Engineering Works will erect a large steel plant for the Tanta Iron & Steel Company. The plant will be erected here and then shipped to a site near Calcutta, India. It will include one 1300-ton metal mixer, two 25-ton inverters, and one 200-ton rolling open-hearth furnace.

PHILADELPHIA.—Charles Lennig & Co., Inc., 112 South Front Street, Philadelphia, manufacturer of nitric and mixed acids, will build a new one and two-story plant, 40 x 70 ft. and 20 x 20 ft., respectively, at Bridesburg. Plans now being prepared.

PHILADELPHIA.—The Asbestos Products Company, Philadelphia, has been incorporated with a capital of \$24,000 to manufacture asbestos goods. H. R. W. Smith, Norristown, is the principal incorporator.

PHILADELPHIA.—Contract will soon be let for erecting one, two and four-story brick and reinforced concrete, 60 x 320-ft. factory building for the American Metal Company. Kern Dodge, engineer.

PITTSBURGH.—The Pittsburgh Plate Glass Company, Pittsburgh, is reported planning the erection of a new plant near Shannan Avenue, Newark, N. J., to cost \$100,000. Application has been made to the local board of works to grant permission to the Lehigh Valley Railroad to extend its line to accommodate the proposed works.

The extraction of gasoline from natural gas is increasing in all sections where oil and gas are produced. In the old districts where production has been only a few wells they find it profitable to locate a plant and derive as much revenue from the gasoline as the oil production. The production is sold principally to the refiners and the price ranges from \$8.00 to 9 cents a gallon. The United Fuel Gas Company, a subsidiary of the Columbia Gas & Electric Company, is the largest producer in the eastern U. S. For the months of January and February this company claims to have made 1,929,048 gal. of gasoline. The Ohio Natural Gas Company is the next largest, with a production of 1,800,000 to 3,500,000 gal. a day. Other companies with not so large a production are: Carter Oil Company, 10,000 gal.; People's Natural Gas Company, 2,000 gal.; West Virginia Central Gas Company, 3000 gal.; Reserve Gas Company, from 8000 to 10,000. The Philadelphia company is installing five large plants in West Virginia and the manufacturers Light & Heat Company three

In southeastern Ohio and southwest Pennsylvania there are many plants building. The production of gasoline from natural gas promises to be a double that of last year. Many operators who have installed gasoline plants claim that the gasoline recovered from casinghead gas is of a value to not only pay all of the overhead charges for operating the oil wells and a profit besides. Wells so light in oil production as to make almost unprofitable to operate still have a good volume of gas that can be converted into gasoline.

Texas

SAN ANTONIO.—Under the new corporation laws it is believed that it will be possible for the largest oil corporations, including the Standard, Pierce and others, to re-enter the Texas field. They planned to spend several millions of dollars in improving their facilities in this state. Pierce-Fordyce Oil Association contemplates spending at least \$1,000,000 in enlarging refineries.

Utah

SALT LAKE CITY.—The Garfield copper smelting plant of the American and Refining Company will be enlarged in order to increase the capacity by 40 per cent. The Murray lead and silver smelter will also be greatly enlarged, as it is running to capacity at present at 1000 tons per day.

Virginia

NORFOLK.—The Mexican Petroleum Corporation has been authorized to do business in the State. The capital stock of its Virginia business is \$2,000,000. The company recently purchased property along the southern branch of the Elizabeth River and will shortly commence the erection of a large plant.

Washington

SEATTLE.—The American Glass Company, which started its business here six months ago, has developed into a strong manufacturing concern. The company has a modern plant, and while it does not manufacture glass it prepares same for commercial use on a large scale. The company has developed a large export trade.

SEATTLE.—The Arizona Smelting & Refining Company is planning the manufacture of ferro-alloys. It will obtain manganese ore from Japan and expects to make ferro manganese, ferro chrome, and ferro tungsten. A temporary plant is located at 245 Ewing Street. It is expected to erect a permanent plant in the near future.

SEATTLE.—The U. S. Bureau of Mines Station here will have a force of nine men. It will also have one man, Mr. J. A. Davis, Fairbanks, Alaska; one or two men at Moscow, Idaho, at the university there, and two men at Corvallis, Ore., at the State College.

SEATTLE.—The Pacific Metal & Galvanizing Company has been recently organized in Seattle. The company will construct a plant at Hanford Street and Whatcom Avenue. The first unit will consist of equipment for galvanizing by hot dip process with a capacity of 100 tons per annum. The officers are: President, C. B. Rhodes, formerly assistant to president of Seattle Drydock & Construction Company, and Henry L. Gray, secretary and treasurer.

SEATTLE.—Rothert Steel Process Company is installing a 2-ton Wile furnace in its plant at South Seattle. The company will manufacture high-grade tool steel from titaniferous ore. It is planned to later install three 10-ton furnaces.

West Virginia

RICHWOOD.—The William F. Mosser Company will enlarge its tannery at a cost of \$250,000.

Wisconsin

MILWAUKEE.—The Federal Pressed Steel Company has purchased five and one-half acres on Booth and North Pierce Streets, which will double its present acreage.

The Wisconsin Metal Refining Company has moved into its new plant at Fraternity and Franklin Streets.

OSHKOSH.—Joseph Hanser of Milwaukee has established a line for the manufacture of potash from wood ashes.

Manufacturers' Notes

B. F. STURTEVANT COMPANY of Boston, Mass., has just completed manufacture of special equipment for the China-American Products Company of Shanghai, China. The equipment consists of a large tank connected to exhaustor, and is used for drying eggs. The eggs are cracked and shells removed, and the contents poured on trays. The air is then passed over them, absorbing the moisture. The apparatus has capacity of 800 eggs per hour. The dried product is canned and exported to U. S. A.

TAKAMINE LABORATORY, INC., 120 Broadway, New York City, has been appointed the sole distributing agent in the United States and Canada, of the products of the Japanese government's dyestuffs company. Dr. Takamine has been appointed on the board of directors.

NEW DIRECTORS IN INDUSTRIAL ALCOHOL.—At the annual meeting of the stockholders of the United States Industrial Alcohol Co., Edward W. Edwards, W. McKenna, W. S. Kies and R. P. Tinsley were elected directors in place of Frederick S. Flower, Crawford Livingston, Julius Kessler and James F. McGovern, resigned. With these exceptions the retiring directors were re-elected. One of the officers of the company made the following statement: "In view of the increasing importance of the company's export business and because of the foreign trade facilities and organization of the American International Corporation, two officers of that concern, Messrs. Kies and Tinsley, were invited to membership on our board. Mr. Harden is connected with the banking firm of James B. Colgate & Co., and is a brother-in-law of President Vanderlip of the National City Bank. Mr. McKenna is an engineering expert."

BRADFORD DYERS' ASSOCIATION MEETS.—The annual meeting of the Bradford Dyers' Association (Ltd.) was held in London, England, on February 27. The chairman had the following to say concerning the British dyestuff industry.

"After two and a half years of war, so far from our industries having collapsed, they are in a more flourishing condition than in any previous period of our history; but great as has been the progress in the manufacture of aniline colors, it is to those engaged in such manufacture, it might unquestionably have been greater, in spite of the prior claim on many materials for the manufacture of explosives, had the war been followed which the accredited representatives of practically all the color users in the United Kingdom and Ireland have insisted on and persistently urged upon the color-making companies, namely, the consolidation of all their interests in one company, thus preventing overlapping and waste of effort. Instead of this, we have seen three such companies employing on the same problems their cleverest chemists, whose activities by a co-operative arrangement would have been spread over a wider field of research. The result is that at the present time two of the concerns are wasting money in rival advertisements announcing their success in the manufacture of certain colors. They were generally supposed to present the greatest difficulties."

"At the same time we learn that a private company in Carlisle, whose only interest in the manufacture of dyes before the war was that of users, seeing its business faced with ruin by its inability to obtain the continental dyes in the use of which it had specialized, determined to start such dye for itself, and it has entirely succeeded; not only so, but in one color of vital importance it has improved upon the best foreign make. These facts surely are proof that there are no insurmountable difficulties in covering the whole field of color production."

"With an unprecedented output of dyed goods, we can not to-day in one sense be said to be suffering from a lack of dyes. With the exception of America, Great Britain is at the moment the only serious producer of dyed textiles for export, and the abounding prosperity of the American people enables them to consume practically the whole of their production. It follows, therefore, that neutral markets are available to take the limited range of colors we can offer, greatly to our temporary advantage and profit, as it requires no expert knowledge to appreciate the fact that our gain is great by having 10 to 20 shades of color as compared with six to eight times that number. But immediately the war is over we must be in a position to offer the widest range of colors; otherwise our position will become most serious by placing a great volume of our export trade in jeopardy."

One point vitally important to the future peace of the dyeing industry is the need of securing the most ample supply

of benzol at a price which would enable colors to be manufactured as cheaply as in Germany. The chairman therefore urged that the present control of the British Government of the production of benzol should not be relinquished before the fullest safeguards to the dye-making industry have been established, and that without delay some authority should be set up to study closely and report upon the various methods by which benzol is now being produced under the pressure of war. It will be a view of determining authoritatively which is the best. As to the problems arising after the war, the chairman referred to the competition that will have to be met from the United States, Japan, Holland and Germany.

ANTI-ACID VALVES.—The Lunkenheimer Company of Cincinnati, Ohio, state that during the past year, there was an extraordinary demand for valves made entirely of iron for use in handling cyanides and other solutions which attack metals having copper as their basic element. This company suggests the use of iron valves in dye and chemical manufacturing plants, but the demand was not confined to these sources as quite a number were also supplied for use in mines, oil refineries, tanneries, pulp and chemical fiber mills, canning and packing establishments, etc.

They maintain large and well equipped chemical and physical laboratories through the aid of which they are enabled to furnish valves and fittings of such materials as best adapt them for the handling of various corrosive solutions.

For use in handling the more severe solutions, such as caustic soda, caustic potash, soda-ash and other similar alkaline liquids, the company employs a composition known as "Lunkenheimer's Nickel-iron." This has exceptional acid-resisting qualities and the long and satisfactory service rendered has led many to use valves made of this material even for the weaker solutions.

A. J. CORCORAN, INC., Jersey City, N. J., will remove its office on May 15th from 11 John Street, New York City, to the factory at 761 Jersey Avenue, Jersey City. The new offices provide better facilities for handling the business goods.

THE GERMAN-AMERICAN STONEWARE WORKS, 50 Church Street, New York City, has changed its name to the General Ceramics Company.

Manufacturers' Catalogs

N. Y. REVOLVING PORTABLE ELEVATOR CO., 379 Garfield Avenue, Jersey City, N. J., has issued Bulletin No. 50 entitled "The Revolver." It describes the company's portable elevators, which are made of steel, and are mounted on a revolving base, for use in piling barrels, boxes, etc.

SCHAAR & COMPANY, Chicago, Ill., have just issued a catalogue for exclusive sale to universities and colleges, containing glassware and porcelain which they are now able to import on the "duty free" basis. This catalogue is unique in that it is the first time in the history of the apparatus business that such a catalogue has been issued solely for "duty free" importations.

THE SOLVAY PROCESS COMPANY, Syracuse, N. Y., has issued a very interesting booklet entitled "Solvay Alkalies."

It gives a short history of the various alkali products produced by this company, illustrations of the various plants, notes on alkalimetry, and chemical and commercial tables converted into English.

THE DIAMOND POWER SPECIALTY COMPANY, Detroit, Mich., has issued Bulletin 117, entitled "Increasing To-Day's Profits." This bulletin describes the company's soot blowing machine, which has also been issued, describing Diamond Soot Blowers for Babcock & Wilcox Boilers.

THE LINK-BELT COMPANY, Chicago, Ill., has issued Book No. 120, describing the Pack Carrier for coal, coke, ashes, cement, sand, stone, ore and other materials.

THWING INSTRUMENT COMPANY, 3339 Lancaster Avenue, Philadelphia, Pa., has issued a bulletin describing pyrometers for clay burners.

Other New Publications

CORALIT, MOLYBDENUM, TIN, TITANIUM, TUNGSTEN, RADIUM, URANIUM AND VANADIUM in 1915. By Frank L. Hess. This is issued by the Department of the Interior, Washington, D. C.

THE RUTHERFORD ACT BY PRODUCTS in 1915. By C. E. Leshar. Issued by the Department of the Interior, Washington, D. C.

GOLD AND SILVER in 1915 (General Report). By H. D. McKay and J. P. Dunlop. Issued by the Department of the Interior, Washington, D. C.

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Contents for May 1, 1917

EDITORIAL:

The Kansas City Meeting of the American Chemical Society	465
Mental Efficiency	466
British Steel Consolidation	466
The late Anton Eilers	467

READERS' VIEWS AND COMMENTS:

Power of Aluminium Production. By M. M. Haff and C. O. Mailloux	468
Printers' Errors. By Carl Hering	469
Evasion of Patent Suit Decisions. By Parker C. Choate	469
Coming Meetings and Events	470
Program of Detroit Meeting of American Electrochemical Society	470
Award of John Fritz Medal to Henry Marlon Howe	471
The Dyestuff Consolidation	471
Dedication of the Chemical Laboratory of the University of Cincinnati. By E. E. Thum	471
Metallurgy in the Southeast Missouri District	472
New York Section of Society of Chemical Industry	474
Progress in the American Dyestuff Industry	474
The Zinc Works Pottery. By Edward Mackay Johnson	475
The Relation of Research to Everyday Life. By Dr. J. B. Weems	475
Spring Meeting of American Chemical Society in Kansas City	481
Benzene, Toluene and Xylene from Petroleum. By Gustav Egloff	492
The Embrittling Action of Sodium Hydroxide on Mild Steel and Its Possible Relation to Seam Failures of Boiler Plate. By Paul D. Merica	496
Grain Size Determination and Standardization. By Zay Jeffries	503
The Japanese Chemical Industry. By Professor Dr. H. Nishida	505
Oxidation and Reduction in Physical Chemistry—Consistency of Terms and Conceptions. By Carl Hering	507
Manufacture of the Electric Furnace at Domnarvret, Sweden	509
Synthetic Rubber. By Andrew H. King	511
Effusion Method of Determining Gas Density. By Junius D. Edwards	518
Recent Advancement in Leather Manufacture. By Allen Rogers	524
Nitrile Industry in Chile	525

SYNOPSIS OF RECENT METALLURGICAL AND CHEMICAL LITERATURE

RECENT METALLURGICAL AND CHEMICAL PATENTS	531
Electric Steel Progress in England	533
Palladium-Gold Crucibles as Platinum Substitute	533
Hydraulic Asbestos Press	533
An Automatic Pressure Regulator for Pulpwood Grinders	534
An Interesting Application of Portable Elevators	535
An Instrument for Indicating Jig Performances	535
Metallurgical Fellowship at University of Utah	536
Accurate Determination of the Critical Point During Annealing	536
PERSONAL	536
BOOK REVIEWS	537
CURRENT MARKET REPORTS—The Iron and Steel, Non-Ferrous and Chemical Markets	537
INDUSTRIAL—Finance, Construction and Operation and Manufacturers' Notes	541

The Kansas City Meeting of the American Chemical Society

The spring meeting of the American Chemical Society was characterized by the very sincerity and earnestness that was to be hoped for from the chemists of a nation at war. The arrangements had been well and intelligently made, and the program was faithfully carried out. The Council met for dinner on the evening of the first day as guests of the Kansas City Section, at the University Club, and convened at Hotel Muehlebach at 8.15, as appointed. The session lasted until after midnight, a great deal of business was transacted with neither undue haste on the one hand nor acrimonious dispute on the other, and the leading thought at all times was how the members of this great chemical body may best render service to the government and the country. President Stieglitz is entitled to the highest praise for the wisdom, large intelligence and patriotism of his leading.

The following resolutions were passed in council and confirmed at the general meeting on Wednesday morning:

"Resolved, That we reaffirm the tender to the President of the United States of the services of the members of our society in all fields in which we are qualified to act.

"Resolved, That the security and welfare of the country demand the organization of all men and facilities of the United States as to secure the greatest possible service and value from each. The progress of the war thus far principally teaches us that modern warfare makes extraordinary demands upon science, food supply and finance. For the protection and success of our men under arms we recommend the use in their respective fields of all trained chemists, physicists and medical men, including advanced students of these subjects. To this end, in collaboration with the United States Bureau of Mines, we are preparing a census of chemists. With no desire to avoid field service for men of training in the professions named, we urge that those of ability be held to the work they can best perform. Thus we may avoid unnecessary loss from lack of control of the tools and requirements of war.

"Resolved, That the attention of the National Council of Defense be called to the scarcity of platinum under existing conditions and to the great need of the metal, more particularly in the prosecution of the war. We hold that its use at this time in the production of articles of ornament is contrary to public welfare. Therefore we recommend that an appeal be made to the women of the United States to discourage the use of platinum in jewelry, and that all citizens be urged to avoid its use for jewelry, for photographic paper, and

for any other purpose whatever, save in scientific research and in making of articles for industrial needs."

The professional sessions are reported very fully elsewhere in this issue, with abstracts of papers and discussions. Many of the papers from the various fields of chemical research were of distinct interest, although no report of any very marked or revolutionary achievement in science was recorded. There was the usual smoker, at which the members of the local section and students from the universities of Kansas and Missouri made merry, but within reason and propriety. All of the entertainments were "dry." At the banquet the note of preparedness was again dominant in all of the speeches. The toastmaster was Ex-President Herty, who presided with skill and facility. President Stieglitz gave some interesting notes on the history of the war and on conditions to-day. Professor Burbank of the University of Kansas told how that institution was contributing to the solution of problems of the day, and Prof. E. W. Washburn of the University of Illinois outlined the errors that had been committed, from a chemical standpoint, in the early days of the war, and pointed out how to avoid them as well as some of our present weaknesses. Mr. Ellwood Hendrick spoke on the need of publicity in chemistry and how to bring it about. Mr. J. H. Atwood of the Kansas City bar, brought a measure of eloquence and wit as well as real fervor to the need of preparedness that all will remember. Colonel Kealy of Kansas City closed with an appeal for greater co-ordination, and told where revivals of energy and reorganization of methods are desired.

On the whole, it was a good, sincere and profitable meeting—profitable to chemists and also to the country at large.

Mental Efficiency

Verily this is the day of preaching efficiency. We must make efficient use of our raw materials, our intermediate materials, our finished products. A sermon on economy as a phase of national efficiency is scarcely ended before we have to be reminded that this economy means only that we should avoid waste, that we must not economize by curtailing any of our industrial activities. It is all true, no doubt, but while in multitude of counselors wisdom no doubt lies, from multitude of counsels there is likely to arise weariness of the flesh and of the mind.

There we have it. Whose mind is not wearied in these times? The man you chance to meet in a business deal remarks he will make a note—he "can't remember anything these days." What occurred a week ago seems like ancient history. This morning's newspaper is "a back number." Yet of all times this is the time when we should be mentally efficient, which means not to make a greater effort but to accomplish more with the same effort or a less effort. We get nowhere by trying to think more or remember more. We must adapt our processes of thought to new conditions and limitations.

The fact of our entering a state of war instantly sub-

stituted for the old motive forces of the mind an entirely new motive force, that of our joining in a collective effort to accomplish a result for the country. By that change the mind became in reality less efficient, for it was not ordered by training or habit to respond to the new motive force. Unknown to its possessor, the mind has tended to respond to excitement, that is, etymologically, "running out," not the physiological stimulation or the energizing as of an electromagnet. It is the excitement of forgetting things. Such excitement may win battles, by the soldiers forgetting the danger confronting them, but it is not the excitement that helps us think to better purpose. We must study our minds afresh, how they can be made to work best in the new circumstances, the new circumstances that surround the nation, and the peculiar set of circumstances with which the exigencies of the times surround each individual.

Successful men have already trained their minds to be efficient, or they would not have succeeded. What is to be recognized now is that the conditions have been changed and the mind requires a new training that it may do the best work of which it is capable under these new conditions.

British Steel Consolidation

Just as we are thinking of how nicely we are going to avoid the mistakes England made in getting into a state of war, and how differently our industries will be aligned after we have been through the stress, comes the news that the British iron and steel makers are considering an amalgamation. Whether it is a complete merging of ownership or merely a pooling of products that is contemplated is not clear, if indeed the plans have gone far enough to develop into a definite project of either sort. The English have practical examples of the two methods, of the German Verband on the one hand and the United States Steel Corporation on the other. Both have succeeded, but the mode has been different. The German syndicates have succeeded because the plan itself was an excellent one, given the German temperament as the soil in which to flourish. The United States Steel Corporation has succeeded, not by any means through the wisdom of the plan, but through the wisdom that has characterized the administration of the corporation. We strongly doubt whether syndicates like the German would thrive in the United States or a German Steel Corporation would succeed in that country. There are great differences in racial temperament.

A little reflection, however, will show that if the British make the choice whether they will follow the one mode or the other they have only made a beginning in their plans. The circumstances existing are so different from those of the struggling times of peace in which the German syndicates and the United States Steel Corporation were conceived that most of the path toward any kind of an amalgamation that can be consummated are almost altogether unexplored. A few of these differences may be pointed out. The British steel

works are now under strict government control. When the Steel Corporation was formed there was not even the Sherman law—it was only a statute. The Government had lost the Knight Sugar Trust case and had not won the Northern Securities case. The German syndicates disposed of surplus steel by paying bounties on exports. English manufacturers will be kept busy paying taxes to the government. There can be no place in their philosophy for a scheme to give non-producing countries steel cheapened by taxing the home market. The Government will do all the taxing there is room for. The United States Steel Corporation had to be underwritten. That the underwriting was an easy success does not detract from the fact that there was a large and necessary risk to be undertaken. The British iron and steel manufacturers were in comfortable circumstances before the war started, and have made so much money since that they can do their own underwriting.

With no thought of trying to anticipate the plans of our British cousins or of undertaking to give them advice, it does not seem unnatural to suppose that the Kartell system will not appeal as fitting the existing circumstances or those that may be imagined as following the end of the war. On the other hand, a complete merging, the sale of each property in exchange for undivided interest in the whole, would be a half-way measure if it were to embrace but one-half the productive capacity of the country, as is the case with the United States Steel Corporation, and it is admitted that things would have to be different in the United States for our Steel Corporation to be a 100 per cent instead of a 50 per cent interest, and everything to be comfortable for all parties interested.

The British Steel Corporation would have to be under strict Government control, as to the prices it would charge and the wages it would pay. Perhaps such an amalgamation would do its part in helping to solve the intricate problem of wages and working conditions that will confront British industries when the war ends. The British workmen who have stayed at home have given much and have acquired new ideas as to spending money, while the men who have gone to the colors will have passed through an inferno and will be entitled to the best that wise counsel can provide for them.

We have a steel industry of our own, and after the war it is going to face new conditions. Through no wisdom in its plan or constitution, but through wise management mainly and through the proverbial American luck in part, it has succeeded. It was not feeling very successful in 1914. The Steel Corporation has been a balance wheel, to the profit of the other half more than to itself. It is merely the record of easily accessible statistics that when selling prices were low the Steel Corporation's production has been a smaller percentage of the country's total output than when prices were high, and that when export prices were below the domestic prices the Steel Corporation's export greatly preponderated, while lately, when export prices have been the higher, the Steel Corporation's proportion of

the exports has greatly decreased. The existing arrangement is not a good foundation for the pull-all-together that must come after the war. We are going to have our problems.

The Late Anton Eilers

Frederick Anton Eilers who died on April 21 at his home in Sea Cliff, L. I., at the age of seventy-eight years, was the great old man in the metallurgy of lead. Born in Nassau, Germany, in 1839, he received his professional education at the School of Mines of Clausthal and at the University of Göttingen and came to this country in 1859. After various positions as mining engineer (from 1869 to 1876 as Deputy U. S. Commissioner on mining statistics and assistant of Dr. R. W. Raymond) Anton Eilers became associated in 1876 with the late Gustav Billing in leasing the old Germania works at Salt Lake City. In 1879 the Billing & Eilers lead smelter was built in Leadville, Colo. In 1882 Anton Eilers organized the Colorado Smelting Company and built the smelter at Pueblo, Colo. In 1888 he organized the Montana Smelting Company and built a large plant at Great Falls, Mont. After the merger with an East Helena, Mont., smelter and the National Refinery of Chicago, the name was changed to the United Smelting & Refining Company in 1890. All these plants went into the American Smelting & Refining Company upon its organization in 1899, of which Eilers was a director and technical member of the executive committee until the end of 1909 when he retired from active business. But his active interest in the profession to which he had devoted his life remained undiminished in his later years.

Anton Eilers has been called the father of modern silver-lead smelting and as such he will live in the history of metallurgy. It was preeminently Anton Eilers who changed lead smelting from a rule-of-thumb affair to an exact science by working out the theory and practice of slag formation on an accurate chemical basis. By extending immensely the range of ores that could be smelted at a profit and by reducing simultaneously the loss of values in the slag, Anton Eilers was a great and true conservationist in times when the term "conservation of natural resources" had not yet been invented. He proved likewise a great mechanical engineer in furnace design and smelter construction, as was shown by his introduction into practice of the sectional water-jacket of cast iron with flaring lip and of the water-cooled tap jacket. In this uncommon combination of highest ability as a chemist and as a mechanical engineer he was the prototype of the modern chemical engineer many, many years before the name was coined. But perhaps most important of all was his work in training men. He was great at this job all through his life and the famous Pueblo smelter was a veritable metallurgical university with graduates such as Hahn, Sticht, Arthur Dwight, Karl Eilers, among many. Anton Eilers built firmly for the future. The man and his work will not be forgotten.

Readers' Views and Comments

Power for Aluminium Production

To the Editor of Metallurgical & Chemical Engineering

Sir:—I would be pleased to get an explanation of the apparent inequality or variableness in the table entitled "Production Capacity for Aluminium," in Dr. Mailloux's article on page 329 of the issue of March 15, 1917, of this journal.

Why should the production capacity be so widely variant when reduced to horsepower year per ton of aluminium as follows?

Country	Aggregate H.P.	Capacity in Tons per year	Horsepower per Ton Aluminium
France	140,000	19,000	7.26
United States.....	105,000	12,500	8.40
Canada	20,000	2,500	8.00
Switzerland	27,000	6,000	4.50
Germany	5,000	600	8.33
Austria.....	5,000	800	6.25
England	21,000	3,800	5.5
Norway	21,000	2,100	10.00
Italy	4,000	1,200	3.33

I will except Italy—I suggest their figures are overestimated.

It would seem to follow that the stated aggregate power has not the direct bearing on the production capacity that the table would have me infer. Is it possible that there would be a great difference in the methods of producing aluminium by electric power (assuming that the third column in Dr. Mailloux's table does represent electric power)?

The U. S. A. is a fairly high-priced power country, and from these figures the deduction is that they use nearly double the amount of power per unit of aluminium produced as compared with Switzerland. Why?

M. M. HAFF.

Ottawa, Canada.

* * *

To the Editor of Metallurgical & Chemical Engineering

Sir:—Mr. M. M. Haff asks for the explanation of certain discrepancies in the figures deduced by him from the table of production-capacity for aluminium, contained in my article on Electrochemistry and Electrometallurgy in France, on page 329 of your issue of April 15.

It is said that comparisons are sometimes odious. It is well known that they are dangerous and misleading when not properly made. Indeed, they may not only become impossible, but they may even be useless or absurd. The comparisons suggested by the figures in the last column of the table accompanying Mr. Haff's letter seemingly belong in this category.

The figures given in the table of production-capacity for aluminium were not intended to serve any other purpose than that of furnishing general statistical information. Like all figures representing aggregates, they are liable to contain many approximations and not a few inconsistencies which have the effect of making comparisons and deductions from them unsafe and deceptive. In order to have any significance at all, the figures that Mr. Haff has tabulated would need to be prepared by reference to data of entirely different character and quality. The aggregate power-capacity of a plant is, as is well known, a somewhat illusive and uncertain quantity. The problem of estimating the aggregate

power of plants for producing aluminium is not a simple one by any means.

In the first place, it would be impossible to find two plants for producing aluminium that are alike, even in the same country. Each plant has its own characteristics, which reflect the knowledge, experience and ideas of its designer, and embody his views in regard to the amount of reserve or margin in production-capacity, available power, etc., considered suitable for such a plant.

In the next place, the exact amount of power available is oftentimes dependent upon circumstances which are quite beyond the control of the designer. This is particularly true in the case of waterpower, where nature has, in most cases, arbitrarily fixed the total amount of power available, and has also introduced obstacles and difficulties to be overcome in developing this power, which impose limitations on the amount developed, and influence, more or less arbitrarily, the cost of development. In some cases, additional power is easily obtainable, and its cost is very low; in such cases it would be natural to make the reserve of power rather large. In other cases, the additional power may be wanting or limited, and it may also be very expensive; and, therefore, the margin of reserve power must, of necessity, be reduced. Some plants have more power than they need; others have not enough power.

It is also important to distinguish between total production-capacity and actual output. This difference would, of itself, introduce an important correction in Mr. Haff's figure for the HP. per ton, in the case of France. Although, as stated in the article, France had, previous to the war, a total production-capacity of 19,000 tons of aluminium per year, the actual aggregate output from all these plants has never attained that figure. The diagram of aluminium production in different countries given on the same page as the table of production-capacity for aluminium (p. 329), shows that the total production in 1912 (the last year for which statistics are available) was only 13,000 tons. As stated at the bottom of page 329 the French aluminium plants have had to divert a considerable portion of their capacity to other work, owing to the small domestic consumption of aluminium, amounting to only 3000 tons, and the difficulty of finding a foreign market for their output, in competition with the plants producing aluminium in foreign countries.

The figures representing the nominal HP. capacity available per ton of production-capacity in a plant will vary within wide limits for the different plants in any one country. In the absence of full detailed knowledge of the characteristics and peculiarities of every one of the plants, it is impossible to form conclusions as to whether the figure given for aggregate power is right or wrong. It would obviously be necessary to make a rather exhaustive examination and study of every aluminium plant in each country in order to obtain data that could serve as a basis for the figures given by Mr. Haff; and even if one had such accurate data it would still be necessary to state the highest and the lowest values, as well as the average value; and it would doubtless be found that there is considerable discrepancy between the extreme values in each country.

Even if it were possible to obtain the figures of comparison that Mr. Haff has in mind it is hard to see what value they would have. The fact is that the cost of production of aluminium bears little, if any, relation to

the power available. It is, however, directly related to and depends upon the cost of the electrical energy actually used per ton of aluminium produced. If a comparison could be made between the different aluminium producing plants, from the standpoint of the electrical energy actually used in HP.-years or KW.-years per ton of aluminium, it would probably show that the differences between the highest and lowest energy-consumptions are not very large. Even here, however, these differences could not be contrasted and compared without taking into consideration the characteristics of the method or process employed in making aluminium. It is well known, for instance, that the percentage of fluorides of various kinds contained in the bath has a considerable influence on the fusing temperature of the bath; and the melting point, in turn, influences the amount of current, consequently the amount of electrical energy, required to keep the bath fluid. So even in this case a comparison would have little meaning or utility in the absence of complete information in regard to the method or process employed.

In view of all these circumstances it is difficult to see that deductions such as contained in the last paragraph of Mr. Haff's letter are warranted or present any interest. They imply and would require information far more exhaustive and circumstantial than is available or procurable anywhere. The final question is thus seen to be useless. It is consequently unnecessary to consider further the great difficulty, in fact the impossibility, of answering it satisfactorily.

C. O. MAILLOUX.

New York City.

Printers' Errors

To the Editor of Metallurgical & Chemical Engineering

SIR:—In my article on Electrolytic Equivalents of Gases in your issue of April 1, near the top of page 383, the last line of the table should read 12,158 instead of 12,153, that is, it should be 1000 times as great, or else it should read in kilo-ampere-hours instead of ampere-hours.

On the fourth line, near the top of page 383, the word "valences" should be "bonds." The valences alone sometimes do not add up to zero unless multiplied by the number of atoms of an element in a compound, but the bonds always do.

CARL HERING.

Philadelphia, Pa.

Evasion of Patent Suit Decisions

To the Editor of Metallurgical & Chemical Engineering

SIR:—In a recent audience with the president of one of our largest metallurgical industrial corporations I was advised by him that any industry was glad to pay royalty to the inventor, but that when the royalty was demanded by capitalized interests industry sought to avoid recognition of royalty, because it was assumed that the inventor had received compensation, when capital took possession of the invention for exploitation purposes.

This thought struck me as the theoretical basis of corporation conscience relative to research. We see it falling short in practice, because the corporations themselves use every effort to obtain possession of common-commodity inventions on the plea that they desire to protect their practice, but in reality for the purpose of preventing the common-commodity use, dictating what the inventor may receive, and suppressing application to the detriment of the community.

After many experiences I am inclined to feel that the pure thought above expressed by a very able minded

president of an industrial concern is merely an ideal that it is not possible to put into practice; first, because the inventor is unable to develop his metallurgical, and thus expensive research, unless he assigns to selfish industrial interests, and second, because the invention so assigned is fought as a business principle. It is extremely rare to find an inventor with adequate capital to demonstrate his invention; hence, if he refuses to assign, because by so doing he would defeat technical development and community advance, he is denied income, and there results the great loss to community.

Suggestions of union research under special royalty contracts to the subscribers to such union action are not considered.

Industry plainly proclaims: Assign to one of us or you can't have money for demonstration, and if you do assign to one of us all the rest will fight the patents, and you as inventor will get only a good salary until we think we can do without you.

The U. S. patent law is openly defied.

All this has happened to inventions recognized of radical and material value by industry. It is in no way imaginative, and it is entirely within my personal notice.

It seems to me that the position which part of the defendants take in the flotation litigation illustrates this practice, which I have described as existing previous to demonstration, where the inventor alone, with merely his mentality, seeks to get any individual recognition and administer his royalties and is refused such.

In a former article I have analyzed this case and given a remedy (see this journal, issue of March 1, 1917). The Minerals Separation, Ltd., came into possession of valuable patents that were at once seized upon as soon as demonstrated. The courts decide the patents are valid and all users must pay royalty, but many corporations refuse, and openly say they will avoid the details of the court decree by using more than 1 per cent of oil in the circuit.

They talk of a new process, yet perhaps there is no technical reason why more than 1 per cent of oil gives better results, but merely the commercial reason to avoid royalty payments to a capitalized patent interest that must be fought, right or wrong. It reminds one of the present European war, for which no real reason exists, while community interests are wrecked.

It does not appeal to me that the use of an amount of oil in excess of 1 per cent, that is an excess over that really needed to wet and float the mineral, can stand as anything else but an attempt at evasion of the patent and a means of prolonging the industrial war and obtaining a further Supreme Court decision, in the hope that the court may reverse itself, as proclaimed by A. B. C. in a former issue of this journal (February 1, 1917). So long as the excess of oil above that used in wetting and floating the minerals is caught and again used the evasion is clearly a commercial one to avoid royalty, and the use of the legalized patent exists, with infringement evident. Even if the excess of oil is not saved, entailing a commercial waste, the waste appears merely as an evasion of royalty.

In the trend towards socialism and better community protection, it would not appear that the Supreme Court will look upon the so-called new process, involving the use of more than one per cent of oil, with no technical advantage over 1 per cent or less, and obviously greater industrial costs and thus community waste, as anything else but an evasion of its decision and determination to make respected the patent laws of the United States, so long used as a football by industry.

How much better it would be if the idealistic theory of the industrial executive quoted were a fact and in-

dustry should recognize the inventor as an individual, or accept administration of his mentality through impartial boards of trustees and provide such trustees with adequate funds to demonstrate research.

The futile attempts for industry to conduct radical research with beneficial results, with few exceptions, must be very apparent to the impartial or analytical mind.

PARKER C. CHOATE.

Essex, Mass.

Coming Meetings and Events

American Electrochemical Society, spring meeting, Detroit, Mich., May 2-5, 1917.

Award of John Fritz Medal to H. M. Howe. United Engineering Building, New York, May 10, 8.30 p. m.

Technical Association of Pulp and Paper Industry, annual spring meeting, Neenah, Wis., May 24 and 25, 1917.

American Iron and Steel Institute, New York, May 25-26, 1917.

American Institute of Chemical Engineers, semi-annual meeting, Buffalo, June 20-22, 1917.

American Society for Testing Materials, Atlantic City, June 26-30, 1917.

Third National Exposition of Chemical Industries, Grand Central Palace, New York, week of Sept. 24, 1917.

American Institute of Metals and Foundrymen's Association, Boston, week of Sept. 24, 1917.

American Electrochemical Society, autumn meeting, Pittsburgh, Oct. 3-6, 1917.

American Institute of Mining Engineers, annual meeting, St. Louis, Oct. 8-13, 1917.

Program of Detroit Meeting of American Electrochemical Society

The headquarters and registration bureau for the spring meeting of the American Electrochemical Society, to be held in Detroit from Wednesday, May 2, to Saturday, May 5, will be at the Hotel Statler. Arrangements have been completed by local committees of which Edwin L. Crosby is general chairman.

All the sessions of Thursday, Friday and Saturday will be held in the Auditorium of the Detroit Board of Commerce Building, Lafayette Boulevard at Wayne Street.

Wednesday afternoon, May 2, visits are scheduled officially to the Dodge, Packard, Hudson and other automobile plants. Automobiles will leave Hotel Statler at 2.00 p. m. (All expecting to take this trip should notify Miss Edna J. Raybould, Secretary to the Committee on Arrangements, 18 Washington Boulevard, in advance and should designate, when registering, which route they wish to take.)

Wednesday evening, May 2, members and guests are invited to a "Get-together" subscription road-house dinner at "West Wood." The party will leave the Hotel Statler at 6.00 p. m.

Thursday evening, May 3, a smoker will be held at the Hotel Tuller, Roof Garden, at 8.00 p. m.

Friday afternoon, May 4, excursions will be made to electric steel plants, power houses and the Lake Shore Drive.

The annual business meeting will be held on Thursday morning (9.30 a. m.) in the Auditorium of the Detroit Board of Commerce Building, Lafayette Boulevard at Wayne Street. (Report of Board of Directors, announcement of annual election, vote on amendments to the Constitution, discussion of report proposed by

Committee on Public Relations on "Water Power Legislation.")

This will be followed by the Presidential Address of the retiring president, Mr. F. A. J. FITZGERALD.

The following papers will then be read and discussed: J. A. MATHEWS: Comments on the Electrical Steel Industry.

R. F. FLINTERMAN: The Electric Furnace in the Steel Casting Plant.

J. L. DIXON: The Grönwall-Dixon Furnace.

The program of the afternoon session (2 p. m.) contains the following papers:

C. A. BUCK: Ten-ton Girod Furnace at Bethlehem Steel Co.

C. H. VOM BAUR: Rennerfelt Electric Furnace Operation.

A. A. MEYER: Restifying Action of the Arc in Electric Steel Furnaces.

R. G. WILLIAMS: Grinding Wheels.

LIGON JOHNSON: The History and Phases of the Smoke Problem.

W. W. STRONG: Theoretical Aspects of Electrical Precipitation.

In the session on Friday morning (9.30 a. m.), the following papers will be read and discussed:

W. R. MOTT: Chemistry of the Flaming Arc in Relation to Luminescence.

W. C. MOORE: The Vosmaer Phenomenon.

O. L. KOWALKE: Acid Corrosion Tests on Some Iron-Silicon Alloys.

E. A. RICHARDSON and L. T. RICHARDSON: Corrosion of Cast Iron and Its Bearing Upon the Electrical Theory of Corrosion.

C. F. HIRSHFELD: Some Low Temperature Electro-Thermic Processes.

W. C. BROOKS: Automobile Storage Batteries.

M. DEKAY THOMSON and L. R. BYRNE: The Current Efficiency in Charging Edison Storage Batteries.

W. L. BADGER: A Switchboard for Experimental Electric Furnace Work.

M. DEKAY THOMSON and T. C. ATCHISON: The Production and Properties of Magnetite Electrodes.

In the evening of Friday (8.30 p. m.) an address will be made by Mr. Alex. Dow, President of the Detroit Edison Company, on "Electrical Power from Coal." Ladies are cordially invited to attend.

For the concluding session on Saturday morning, (9.30), the following program has been arranged:

W. E. KOERNER: Electrolytic Behavior of Tungsten.
M. DEKAY THOMSON and O. L. MAHLMAN: The Electrolytic Pickling of Steel.

F. C. MATHERS and K. S. MEANS: Tests of Antimony Plating Baths.

F. C. MATHERS, K. S. MEANS and B. F. RICHARDS: Electro-Plating from Fluoride Baths Containing Addition Agents

F. C. MATHERS and L. G. BLUE: Addition Agents in the Deposition of Silver from Uncommon Salts.

F. C. MATHERS and A. B. LIBELE: Effect of Essential Oils as Addition Agents.

T. B. BRIGGS, H. L. PIERSON and H. S. BENNETT: Electrical Endosmosis and Absorption.

O. P. WATTS and A. BRAUN: Deposition of Hydrogen in Cyanide Plating Solutions.

T. W. CASE: A Cuprous Oxide Photo-Chemical Cell.

The special program for the entertainment of ladies contains a Lake Shore drive for Thursday afternoon. (Tea at Belle Isle or Detroit Athletic Club.) A theater party for Thursday evening ("Winter Garden Show," and for Friday afternoon a drive through Bloomfield Hills. (Tea at Bloomfield Hills Golf Club.)

Eastern Standard Time is used in Detroit, and is the

time indicated in this program. The railway time table indicate Central Time. Visitors are cautioned to take notice of this fact.

Arrangements have been made with the New York Central Railroad to operate one or more sleeping cars for the exclusive use of members attending the convention from New York City. Special fares will be allowed if the number is large enough. The train recommended is the "Wolverine" leaving Grand Central Terminal 5.00 p. m. Tuesday, May 1, and arriving at Detroit 7.10 the following morning.

Award of John Fritz Medal to Henry Marion Howe

The John Fritz Medal has been this year awarded to Dr. Henry Marion Howe for his investigation in metallurgy, and especially in the metallurgy of iron and steel.

The John Fritz Medal is awarded by the John Fritz Medal Board of Award, which body consists of four members from each of the national engineering societies, viz., the American Institute of Mining Engineers, the American Society of Civil Engineers, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers. It represents the highest reward from the engineering profession for distinguished services.

The presentation ceremonies will take place on the evening of Thursday, May 10, at 8.30 o'clock, in the Auditorium of the United Engineering Building, 29 West Thirty-ninth Street, New York.

Addresses are expected from Dr. Rossiter W. Raymond, Dr. Ira N. Hollis, Judge Elbert H. Gary and Prof. Albert Sauveur. Ladies are specially invited.

The Dyestuff Consolidation

The announcement in our last issue of the merger of the Schoellkopf Aniline and Chemical Works of Buffalo, the W. Beckers Aniline and Chemical Works of Brooklyn, the Standard Aniline Products Company of New York, and the National Aniline and Chemical Company of New York is supplemented by later information which includes in the consolidation the Benzol Products Company of New York and the various processes and interests of the General Chemical Company, Barrett Company and Semet-Solvay Company.

Financial details of the organization of the new company, which will be known as the National Aniline and Chemical Company, Inc., are in the hands of Eugene Meyer & Co., bankers of 15 Wall Street. The capitalization of the new company has not yet been announced.

The new company will be in a splendid manufacturing position, as it will have the necessary crudes and intermediates produced in its own plants and will have a very large finished dye-making capacity. The following statement was issued to us by I. F. Stone, president of the old National Aniline and Chemical Company, the selling company for the Schoellkopf Aniline and Chemical Works.

"A company is being formed known as The National Aniline and Chemical Company, Inc., to take over the Schoellkopf Aniline and Chemical Works, with its line of dyestuffs; the W. Beckers Aniline and Chemical Works, with its line of dyestuffs, and the Benzol Products Company, producers of aniline oil and salts and also of certain of the coal tar intermediates—these three concerns in their entirety. It will also acquire certain minor interests and processes in coal tar intermediates already developed and developing of the General Chemi-

cal Company, the Semet-Solvay Company and The Barrett Company.

"This company will be in a position not only to make the intermediates and dyestuffs now being made by those concerns, but it hopes to be able ultimately to extend its field to other intermediates and other dyestuffs, as well as to pharmaceutical products and photographic chemicals and coal tar explosives.

"The businesses and processes of the various concerns thus taken over, each being engaged in a separate branch of the industry, fit into and supplement one another, and the new company thus formed will be a highly integrated concern, as are the large dyestuff companies of Germany, which prior to the war practically controlled the entire business of the world in dyestuffs, coal tar intermediates and the like.

"It is the hope of the parties interested that with a continuation of the friendly co-operation of the Government and of the consumers of dyes of the new company and others in the field will be able to meet on even terms after the war the competition of those foreign concerns that formerly controlled the business. The parties interested not only are endeavoring to retain for the United States as much as possible of the business which war conditions have enabled them to develop in a temporary way, and precariously, but also to supply the need of late so acutely felt in this country for a coal tar color and chemical industry highly developed in all its branches."

Dedication of the Chemical Laboratory of the University of Cincinnati

On Saturday, April 7, 1917, dedicatory exercises were held at the University of Cincinnati, formally opening the new chemical laboratory, which, however, has been occupied by the chemistry and metallurgical departments* since the opening of the current school year. The exercises were held in the auditorium of the University, following a public inspection of the new building and its equipment.

In a few words, Mr. Robert Hochstetter formally presented the keys of the building to the head of the chemistry department, Dr. Lauder William Jones. In reply, Dr. Jones sketched briefly the growth of chemistry at the University of Cincinnati since the early seventies under the leadership of Frank Wigglesworth Clarke, Thomas H. Norton and Thomas L. Evans, and accepted the trust left by these distinguished predecessors. As an ideal for the new laboratory he proposed that the value of pure science be continuously emphasized, especially in the teaching and investigation of the so-called applied chemistry, with the understanding that the union of the two is absolutely necessary for lasting progress in the arts.

Dr. John Uri Lloyd then made a few remarks on behalf of the American Chemical Society, in which he spoke of the work of the pioneer chemists of Cincinnati, and how the few survivors of that band were now having their hearts gladdened by this material evidence of the fulfillment of their hopes and expectations.

Dr. Charles E. Herty, past-president of the American Chemical Society, then presented an address on "The Swing of the Pendulum in Chemistry." Dr. Herty described the condition of our infant chemical industries in 1914, prior to the outbreak of the great war, and the hurrying and scurrying incident to shutting off the German chemical importations. An immediate effort was made to produce locally the enormous quantities of chemicals and dyes required by the United States, re-

*A full description of the courses in these departments was published in our issue of April 1, page 367.

sulting in a plant expansion valued at \$200,000,000. Large drains upon the chemical faculties were made by the industries in order to manage this large increase in plant capacity—at the same time the importance of applied chemistry in our national life was influencing hundreds of young men to enter chemistry and chemical engineering. The result is now found to be laboratories overcrowded with students and undermanned with instructors.

For the good of the industry as well as of the University (for the industry will make small progress without a sound foundation built upon academic training), it is absolutely necessary that the pendulum now swing back to the University. It is necessary that boards of trustees and executive officials make a strenuous effort to counteract the attraction which the industry exerts upon their teachers by raising salaries, furnishing more laboratory assistants and new equipment to handle the larger number of students, and providing their faculties with materials and time for research in their chosen fields. Otherwise the continued exodus of chemists from teaching into practice will ultimately spell disaster for both.

At a banquet tendered by the Cincinnati Section of the American Chemical Society during the evening, Dr. Alfred Springer presided as toastmaster. He called attention to the present necessity for the chemist to help the farmer rather than the urbanite by devoting his efforts to the production of synthetic fertilizers by fixation processes, calling attention particularly to the work recently published by Bucher of Brown University.

President Charles W. Dabney, responding to "Chemistry in a University," pointed out the immense services rendered by the science of chemistry to human thought and life in general by establishing an absolute freedom in the right to experiment and think inductively in the search for truth, no matter where that search led or what idols it destroyed.

Prof. L. W. Jones described the transmutation of the "base" employee in a dirty hole who analyzed the pig iron to the "noble" investigator of the modern research laboratory.

Dr. Martin Fischer called attention to the ancient Chinese idea that the true value of human effort may be appraised thus: first, that of the scholar, who produces values out of nothing; second, of the farmer, who produces out of the earth; third, the artisan, who shapes cunning things from rough materials; and lowest, the merchant who, in his effort to buy cheap and sell dear, cheats both sides. Unfortunately, as measured by our present standard of monetary return, the value of these classes to our civilized world seems to be in the inverse proportion to that existing in olden times.

E. E. THUM.

Promotion of Research at Universities

The National Research Council established by the National Academy of Sciences at President Wilson's request to organize the scientific resources of this country in the interest of preparedness and to foster scientific and industrial research through co-operation, and by other means, has asked all the important universities, colleges and scientific schools to appoint committees consisting of members of their faculties and boards of trustees to consider and report on methods by which research can be best promoted within the institution. These have already been appointed at many institutions. The University of Pittsburgh has appointed Messrs. Bacon, Brashear, Griffin, Guthrie, Holland, Lincoln, Schlesinger and Thorpe, with Dr. George H. Clapp as chairman. The Massachusetts Institute of

Technology has appointed Messrs. J. R. Freeman, F. R. Hart, A. D. Little, C. T. Main, G. E. Hale, W. R. Whitney and Jasper Whiting of the alumni, and Professors Cross, Kennelly, Lewis, Lindgren, Noyes, Riley, Whipple and Wilson of the faculty. President MacLaurin is chairman of this committee.

Metallurgy in the Southeast Missouri District

If there is anyone who does not know yet that St. Louis is a mining and metallurgical center of greatest importance, and that, for instance, the southeast Missouri district, about 80 miles south of St. Louis, is the largest lead district in the world, he will learn all about it before the meeting of the American Institute of Mining Engineers, to be held next October in St. Louis, is over.

The members of the Institute living in the lower Mississippi Valley have already started in making preparations for the meeting and are extending a hearty and cordial invitation to their fellow members to meet with them in St. Louis. It will be a meeting of singular interest inasmuch as the district in question can show in active production almost all of the more useful metals and non-metals.

To the publicity committee of the Institute (Mr. J. D. Robertson, chairman) we are indebted for the following notes on the southeast Missouri lead district and for the photographs reproduced on the adjoining page.

During the St. Louis meeting a special trip will be made to the southeast Missouri district. This was already the largest lead district in the world before the European war, and now that the production of lead has greatly decreased abroad, and has correspondingly increased in the United States, this is one of the most interesting of all lead districts.

In 1913 the production of the world was 1,270,000 tons, the last world figures obtainable. In that same year the production of the United States was 412,000 tons, and of southeastern Missouri 133,000 tons. In 1916, the world's production having fallen off, the production of the United States was over 600,000 tons, and that of southeastern Missouri 184,000 tons (32 per cent).

In view of the great necessity for lead at present, and so far as we can foretell for the future the possibilities not only in this known district, but in contiguous areas, are not only interesting but decidedly important.

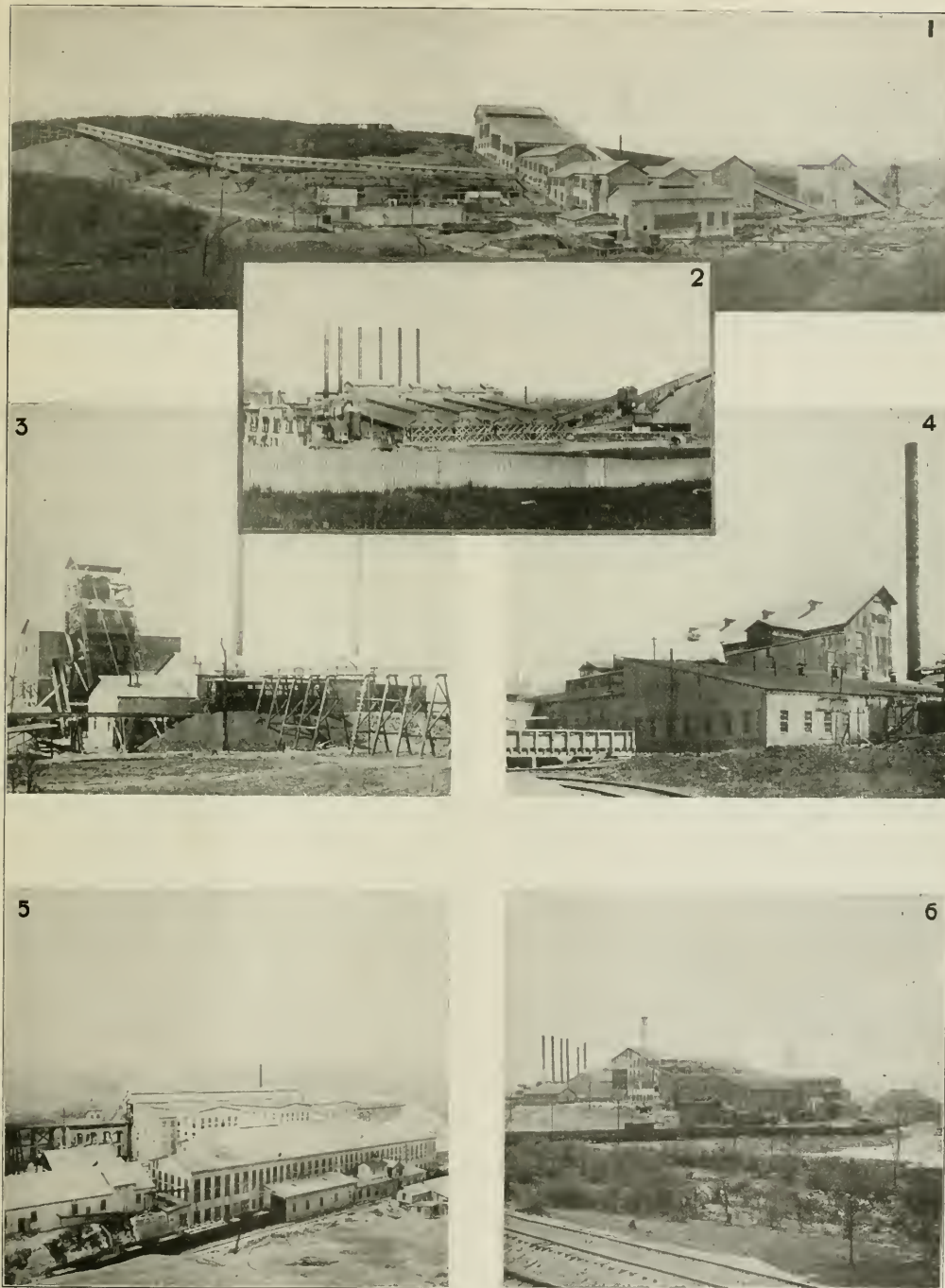
The ore occurs not in veins, but disseminated through a great bed of magnesian limestone, more than 400 ft. thick in places, and when mined only carries an average of about 3 per cent lead. It has taken nearly a generation to perfect the concentration plants, and the managers do not consider them perfect yet. Here this ore is crushed and cleaned until it will run about 70 per cent lead. There are some very interesting developments in flotation in progress at these mills, and nearly one-tenth of the clean ore shipped to the smelters is produced by flotation.

The resulting ore is smelted at the various plants of the different companies, located at Herculaneum, Alton and Collinsville, with a combined capacity of 250,000 tons of lead per year.

These smelters will all be visited on the occasion of the meeting.

The uses of the lead finally are interesting. Just now its tremendous importance as a war material overshadows the fact that probably one-half of the product goes into the form of white lead and other kinds of paint.

Much is used as anti-friction metal and as pipe and sheet.



METALLURGICAL PLANTS IN THE SOUTHEAST MISSOURI DISTRICT

No. 1. Mill No. 4 and Shaft No. 12 Federal Lead Co., Elvins, Mo. No. 2. St. Louis Smelting & Refining Co., St. Francois, Mo. No. 3. Shaft No. 3 Desloge Consolidated Lead Co., Desloge, Mo. No. 4. Power House and Mill, Desloge Consolidated Lead Co., Desloge, Mo. No. 5. Mill No. 3 St. Joseph Lead Co., Elvins, Mo. No. 6. Mill No. 3 Federal Lead Co., Flat River, Mo.

New York Section of Society of Chemical Industry

Colloid and Emulsion Chemistry

The New York Section of the Society of Chemical Industry held a joint meeting with the New York Sections of the American Electrochemical Society and the American Chemical Society on Friday evening, April 13, at the Chemists' Club. The chairman, JEROME ALEXANDER, presided. Considerable interest was shown in the subjects presented, the hall being crowded. A short business meeting preceded the presentation of papers.

The following officers were elected for the ensuing year by the New York Section of the American Electrochemical Society: Chairman, J. V. N. Dorr; vice-chairman, E. D. Kingsley; secretary-treasurer, J. Malcolm Muir.

Officers for the ensuing years for the New York Section of the Society of Chemical Industry were elected as follows: Chairman, Jerome Alexander; treasurer, F. C. R. Hemingway; secretary, Allen Rogers.

The first paper of the evening was presented by Dr. ALLEN ROGERS of Pratt Institute, Brooklyn, on "Recent Advancement in Leather Manufacture." This paper is published in full on pages 524 to 525 of this issue.

Prof. MARTIN H. FISCHER of the University of Cincinnati, presented a very interesting address on "Some Technological Aspects of Colloid and Emulsion Chemistry," illustrating his talk with many experiments and the exhibition of many samples. He first took up the type of colloids known as suspensoids, in which a solid is suspended in a liquid. He took up the subject of water absorption by protein colloids and the effect of adding various reagents in producing or hindering swelling in proteins and carbohydrates and explained that the swelling of tissues is analogous to water absorption by proteins.

In taking up the general subject of emulsions Professor Fischer said the great question was how to stabilize an emulsion, such as, for instance, oil in water. Three methods have been proposed for doing this: (1) By adding an emulsifying agent; (2) by using a viscous liquid; (3) by reducing the surface tension, as in adding soap to water. These ideas all suffer shortcomings, according to Professor Fischer, and do not account for the action of all emulsions.

He said that all that is necessary is to have a colloid hydrate or so-called hydrophilic colloid present, which takes up the water, and thereby reduces the number of phases. An emulsion breaks whenever the hydrophilic (lyophilic) colloid which holds the aqueous dispersion means is either diluted beyond the point at which it can take up all the offered water, or is so influenced by external conditions that its original capacity for holding water is sufficiently reduced. Thus dehydration of the hydrophilic colloid can be accomplished by acids, alkalis and salts.

It is then possible, for instance, in a soap emulsion to separate out the oil by adding an amount of water so great that it cannot all be combined in the colloid hydrate. Soaps are hydrophilic in high concentration only, so we get the separation by adding enough water.

As an example of dehydration he took the system oil-water-neutral casein. These three mixed together do not form a colloidal emulsion. If we add, however, some alkali or acid and make an alkali or acid colloid hydrate, then emulsification will take place. Acid will dehydrate the alkali-casein and vice versa. There is a minimum amount of hydrophilic colloid which will give the complete emulsification. Professor Fischer illustrated this

point by a number of experiments with various substances.

He explained the determination of rubber to be the cracking of the emulsion. Emulsions of oil in soap are found to have great resiliency which can be felt if a bottle of it is tapped on the table, but when cracked this resiliency disappears. Acids and various salts will crack these soap emulsions, as will also calcium hydrate and alcohol. Caustic soda will not crack them. Ether is relatively ineffective. Calcium soap is not a hydrophilic colloid, consequently the addition of calcium hydrate will crack the emulsion. The fact that alcohol and ether are by themselves thus relatively ineffective in breaking emulsions explains why the ordinary fat extraction methods are so often only partially effective in getting the fat out of biological materials, and why previous treatment of the material, as by digestion with strong acids or alkalis and by similar methods, yields higher fat figures than extraction with ether or allied materials alone.

Dr. ALEXANDER gave a demonstration of the Zsigmondy-Brownian movements, having an ultra-microscope present on the table, through which anyone who cared to could see this interesting phenomenon after the meeting.

Progress in the American Dyestuff Industry

At a meeting of the Providence Engineering Society at Providence, R. I., on Friday, April 20, Dr. JOHN C. HEBDEN, the distinguished vice-president and general manager of the Federal Dyestuff & Chemical Company, of Kingsport, Tenn., gave an interesting address on the past, present and future of the American dyestuff industry. As Dr. Hebdén is the creator of the large works of the Federal Company at Kingsport, he speaks with authority. He said in part:

"At the beginning of the war the American chemist was considered to be unable to produce or manufacture dyestuffs or any of the finer chemicals. The world's production of dyestuffs was divided about as follows: Seventy-five per cent were made in Germany, or in concerns absolutely under German control in countries outside of Germany; 20 per cent were made in Switzerland or in concerns controlled by the Swiss capital. This, in spite of the fact that Switzerland possesses not one pound of coal nor one pound of raw material suitable for the manufacture of dyestuffs. The balance of the world's production was manufactured in countries outside of Germany and not under control. In this country, owing to a very unfair tariff legislation, 10 per cent of the total dyestuff consumption of the country was manufactured in the United States, and a large proportion of this product was manufactured from intermediates imported mainly from Germany.

"In spite of the handicaps under which the American chemist was obliged to undertake the manufacture of dyes, the American public immediately, at the outbreak of the war, demanded of him to do miracles and to save the country. Immediately, when he began to undertake this industry, he was confronted with an enormous demand for the raw materials which go into the manufacture of dyes from the munition manufacturers, that is, from the manufacturers of picric acid and trinitrotoluol.

"The result of this demand was that the price of benzol was from four to five times its normal price and the price of toluol from five to ten times its normal price. Therefore, he was compelled to begin the manufacture of dyestuffs from those intermediate products which would naturally be developed through the manufacture of high explosives.

"This made the development of the manufacture of dyestuffs follow parallel with the manufacture of high explosives, and during the year 1915-16 the development of a full line of so-called sulphur dyes was the result.

"These colors alone would comprise about 10 per cent of the total dyestuffs consumption of the country. Because the products used in the manufacture of some of the finer grade of high explosives could be used, a line of dyestuffs, substitutes for alizarines, but not true alizarines, were developed. Together with these colors, principally used for wool, were developed certain dyes for cotton known as the basic colors.

"All this development took place without any particular encouragement or assistance from the textile trade. The paint makers, however, realizing the seriousness of the situation, together with the ink manufacturers, started development of those products which are not used in high explosives, and produced colors used in their trades. Too much credit cannot be given to these manufacturers for their courage and their successful efforts.

"At the present time development is taking place along the line of those intermediates or products which are not so essentially a part of the high explosives business, so that the country will shortly be supplied with true alizarine, after chroming dyes for wool and for the fast acid colors for wool and the fast direct colors and developing colors for cotton. As soon as these intermediates are developed, the number of dyestuffs will be multiplied very rapidly.

"During all this development the American public has failed to realize the importance of the dyestuff industry. The propagandists representing the importers who, before the war, controlled the distribution of dyes, not only in this country but practically throughout the world, first preached the doctrine that colors could not be made in America, particularly the alizarine colors, in spite of the fact that years ago anthracine was made in this country and exported abroad and the alizarine made therefrom imported.

"The textile trade failed to realize that the people who manufactured and sold dyestuffs dictated absolutely the textile policy of the country, and while they were listening and believing those who were declaring that dyestuffs could not be made in this country, they were also listening to the argument that the dyestuff consumption of the country was a small matter anyway, and that the manufacture of dyestuffs was really a one-nation business. The result of all this propaganda was the utmost indifference on the part of the consumer, even up to the present time.

"The textile manufacturers failed to realize that economic independence is just as essential to the well-being and prosperity of the country as political independence, and, therefore, it is necessary to establish a dyestuff industry which shall supply every pound of dye which we may consume, if we are going to be able to control our textile manufacturing policy and attain our economic independence.

"The reason for the condition which confronted the American people at the outbreak of the war with reference to the supply of dyestuffs was due, first, to the propaganda, and, second, the tariff legislation. The beginning of this tariff legislation in favor of the importer dates to the patent maintained on alizarine and the insertion in the tariff in the free list of artificial alizarine. The importers found the writing of this paragraph in the tariff so easy and having made millions of dollars through their patent, were able by influences to extend not only the term 'artificial alizarine' in the free list, but to include indigo and other

products so that fully one-half of the products manufactured by these concerns and imported into the United States came in duty free.

"As far as the United States was concerned, the pan-American conquest was complete as applied to dyestuffs. Since the war began a tentative revision of tariff has been made, but the same influence which dictated the previous clauses on the free list was able to dictate a joker which would nullify the benefits to be derived from tariff legislation, and place the sulphur colors, which is the largest item developed thus far by domestic manufacturers on the free list, and thus make their manufacture in this country impossible."

Dr. Hebden, in conclusion, emphasized that the development of the dyestuff industry will depend on a tariff written in favor of the American industry and not the importer. This is absolutely necessary for the sake of economic independence of the country.

The Zinc Works Pottery

By Edward Mackay Johnson

The pottery is one of the most important departments of the zinc plant, and has a very decided influence, good or bad, upon the recovery of zinc, especially with reference to making the retorts. Very close watch must be kept every day upon the operations of this department. If this is not done, serious trouble may occur on the furnaces at any time due to bad retorts; and this trouble accompanied by poor recovery will continue for the same length of time on the furnaces, as the cause of it existed in the pottery, and it is a case of having to use these poor retorts until the trouble is rectified. Even where close watch is kept upon the pottery operations, there are times when an abnormal loss of retorts occurs and disappears without anyone being able to trace the trouble.

Pottery Record.—From the preceding remarks it will be seen how important it is not only to keep an account of the retorts and condensers made, but a record should be made each day of what enters into the manufacture of the retorts, and remarks made upon the same. In this way not only will a better retort be made, but any irregularity may be more quickly located.

Very often it is only by a process of elimination that the trouble may be located. In fact this is often true of anything affecting the recovery of zinc.

PREPARATION OF THE CLAY

Most of the zinc plants still continue to obtain their supply of clay from the vicinity of St. Louis. Clays from other parts of the United States are tried now and then on a small scale for the manufacture of retorts. In a few instances satisfactory results have been obtained, and the clays used in actual practice.

Most of the St. Louis clay is well adapted to the manufacture of retorts and especially so if it be properly weathered. In fact there is no doubt but that many of the troubles arising in the manufacture of retorts, as well as the loss due to checking or cracking in the pottery and possibly in the furnace, may be traced to the improper weathering of the clay. In the writer's opinion no clay should enter the pug mill that has not been previously weathered even if the first pugging is permitted to stand for forty-eight hours before repugging. A few cents per ton expended in weathering the clay properly may save a good many dollars in the end. Due to the fact that it is almost impossible to crush and screen wet clay, it is better to have the bins ar-

ranged with roofs, and if necessary artificially assist the weathering by means of water or exhaust steam from the pottery (if it be so heated) permitting the same to come in direct contact with the clay.

After sufficient weathering the same exhaust line might be used to assist in partly drying the clay by simply closing the exhaust valves. If such an arrangement as the above could be used to advantage the pipe line would have to be laid upon the floor of the clay bin, with the exhaust valve openings extending downward and some provision made for regulating them.

ANALYSES

Tables I and II give analyses of clays from which satisfactory retorts have been made at various plants.

TABLE I—CLAY ANALYSES

	1	2	3	4	5	6	7	8	9	10
SiO ₂ ..	55.7	51.0	62.2	61.7	55.4	48.3	51.4	47.4	58.7	56.0
Al ₂ O ₃ ..	29.7	35.6	31.4	29.0	34.3	31.3	30.8	35.8	28.6	27.0
Fe ₂ O ₃ ..	2.7	...	...	3.0	...	...	1.8	2.4	1.6	2.4
FeS ₂ ..	0.6	...	...	...	...	0.36	0.53	0.9	0.38	0.51
CaO ..	...	...	...	...	...	0.32	0.27	...	...	0.52
MgO ..	...	...	...	...	...	...	...	...	...	0.48
Alkali ..	...	...	...	...	...	2.00	2.35	...	...	...
TiO ₂ ..	0.3	...	...	...	...	...	...	0.88	...	...
S ..	...	...	...	...	...	...	...	...	...	...
lg. loss	10.3	...	...	...	...	11.10	...	13.60	...	12.9

TABLE II—RATIONAL ANALYSES

Clay substitute	78.5	75.4	58.5	70.0	64.2
Quartz	17.6	14.5	22.0	24.6	10.4
Feldspar	3.8	8.4	19.5	5.4	24.9

The results are given as they were reported by various chemists at different plants.

It is seldom if ever the case that the analysis of a clay is relied upon to determine its value for the manufacture of retorts. A practical test of the retorts in the furnace is always made. The analysis merely indicates if the test is worth while making.

PHYSICAL PROPERTIES

A good clay in the lump form should have some of its surfaces smooth and should feel like soapstone. It should not feel too gritty when mashed between the teeth. If the lumps are broken open their surfaces should not show any, or at least very little, iron pyrites. Good clay should readily disintegrate upon standing in the air. After the clay is properly weathered it is crushed or rather mashed up with a jaw or hammer type of crusher and elevated to some type of screen, the returns going to rolls. The same screen is used for the clay that is used for the adobes¹, which seldom varies much from a 6-mesh No. 16 wire. In some plants the clay and adobes are crushed separately, and at some they are crushed together in proper proportions. So far as the retort is concerned it is immaterial, provided the proper mix of the ground clay and adobes be charged into the pug mill. The proportion of raw clay to burnt clay varies somewhat according to the physical character of the two substances. As a rule a little more burnt clay is used than raw clay, about 70 parts to 60 parts.

The same machinery used to prepare the clay, including the 6-mesh No. 16 wire screen, serves to handle the burnt clay or adobes as previously stated. Actual practice has demonstrated that it does not pay to get very far away from this size screen. One of the main points to bear in mind is to avoid forming much fine material, especially with respect to the burnt clay, by having ample screening capacity and possibly two sets of rolls.

As the tests of Table III were made at two different plants under different conditions there is naturally a

¹The term adobes here used refers to burnt clay or clay mixed with grog and burnt. The term also refers to what is called chamotte, grog or cement. All of these terms are used indiscriminately at the different plants.

TABLE III—SCREEN TESTS ON CRUSHED ADOBES

Mesh	No. 1 6-Mesh No. 16 Wire, Per Cent	No. 2 6-Mesh No. 16 Wire, Per Cent	No. 3, Piano Wire, Per Cent
On 8	3.00	...	...
On 10	...	16.00	30.8
On 20	55.02	25.90	28.5
On 30	...	26.70	13.5
On 40	21.11	7.30	6.5
Through 40	79.13	75.90	79.3
On 60	8.81	6.60	4.5
On 80	2.51	5.90	6.8
On 100	1.51	2.10	3.0
Through 100	8.04	9.60	6.4
	20.87	25.10	20.7

variation in the results. It is, however, interesting to note that the sum of the material above the 40-mesh screen is very nearly the same in the three cases and that considerable material passes through the 100-mesh screen. It might be well to make an analysis of this very fine product to see if it does not carry a large proportion of the impurities. If so, its removal by suction might make it possible to produce a better retort.

PUGGING

Provided the clay and adobes have been crushed to the proper degree of fineness, it is merely a matter of practical experience and judgment to be able to add the requisite amount of water to obtain the correct temper of the retort mud. The first pugging should stand for at least twenty-four hours (even if the clay had been previously weathered) before pugging the second time. It is customary to endeavor to have the first pugging just soft enough so that when it is pugged the second time the mud will become stiff enough for the retorts without the addition of either water or mix.

MAKING THE RETORTS

Most of the plants have replaced the common retort press with the hydraulic retort press. It is interesting to note, however, that two of the new plants have installed the former; and in one of these cases it was said to have been based on obtaining better results with the common retort. The writer has been connected with three plants that used the common retorts, and three that used the hydraulic, and has come to the conclusion that if a solid foundation be put in, the iron frame work made heavier, and all the parts of the press kept in proper alignment, the common retort may be made practically as good and a little cheaper than the hydraulic pot. With respect to the recovery of zinc, and tonnage handled by the two kinds of retorts, no figures of comparison can be given as no similar conditions existed in any two cases.

DRYING RETORTS

In the construction of some of the potteries in recent years, the old plan of having two or three large-drying rooms one above the other, and transferring the retorts several times in order to dry them slowly, has been abandoned in favor of smaller and more rooms constructed adjacent to each other on the ground floor. The main advantages of this system are as follows: The retorts are handled less, as they are taken direct from the press to these rooms and remain there until taken to the furnaces. The rooms are not so much subject to change in temperature, or drafts. The temperature and drying are more easily controlled.

In either case the drying must be done by degrees, and the retort thoroughly dried. There is no apparent reason why retorts should improve with age, provided they are once properly dried; but as a safe precaution it is best not to use them before they are thirty

days old. One of the most important things to bear in mind, but which is often neglected, is the proper drainage from underneath the pottery floor. Another is that frequently not enough space is left between the ground floor proper, and the floor upon which the retorts set, so that any leaks occurring in the steam or water lines may be readily repaired.

RETORT COST

Apparently the cost per retort has not changed very much in the past ten years, while in reality it has, due to some increase in labor. The quality of the retort should always be the first consideration. This subject will be taken up again under pottery cost.

SIZE AND CAPACITY OF RETORTS

In order to show how the retorts vary in measurement, and therefore in cubic contents, Table IV gives the figures on dried retorts. They represent the average of a number of measurements of retorts at five different plants. The figures given for diameter and length are inside measurements.

TABLE IV—RETORT DIMENSIONS

	Diam., In.	Length, In.	Wall, In.	Butt. In.	Kind	Cu. Ft. Capacity
No. 1.....	8 1/4	45.3	1 3/16	2 1/2	Common	1.360
No. 2.....	8 1/2	48.0	1 3/16	2 1/2	Common	1.576
No. 3.....	7 3/4	49.4	1 1/16	1 1/2	Hydraulic	1.349
No. 4.....	8 3/8	50.5	1 1/16	1 1/2	Hydraulic	1.539
No. 5.....	8 3/5	49 1/4	1 1/16	1 1/2	Hydraulic	1.656
Average...	8 3/16+	48 1/2				1.496

In expressing furnace capacity the term "pounds of ore per furnace" or per retort does not mean very much, and as the following illustration shows it would be more accurate to use the term "pounds of ore per cubic foot of retort or furnace capacity." Assume a plant of ten furnaces and 4000 retorts. Assume 33 lb. of roasted ore per cubic foot. Then taking the highest and lowest cubic foot retort capacity in table IV we would have:

Retort Capacity.	Total	Plant Capacity.	Lb. Per Cu. Ft.	Lb. Per Furnace	Lb. Per Plant
Cu. Ft.	Retorts	Cu. Ft.	Cu. Ft.		
1.360	4000	5140	33	17,552	179,520
1.656	4000	6624	33	21,859	218,592

This shows a difference of nearly 4000 lb. of ore per furnace; wherefore if any very accurate comparisons are to be made between capacities of two furnaces, blocks or plants, it is necessary to know the retort capacity in cubic feet.

CONDENSERS

Nearly all of the plants have installed condenser machines, of which there are two types. As the highest cost per condenser rarely exceeds 5 cents there is very little room for reduction. Sometimes a cheaper grade of clay is partly or entirely substituted for the retort clay in the manufacture of condensers. The grog consists principally of the cleanest of the retorts from the furnace. There is not so much difference in the shape of the condensers at the different plants, as there is in the length. The variation in size would be as stated in Table V:

TABLE V

	Inches
Outside diameter of large end.....	7 to 7 1/2
Inside diameter of large end.....	6 1/4 to 6 3/4
Outside diameter of small end.....	4 1/4 to 4 5/8
Inside diameter of small end.....	2 5/8 to 3 1/8
Thickness of wall.....	3/4
Length.....	17 to 20

These measurements refer to the sizes obtaining at the five plants for which the retort dimensions were given.

CONDENSER LOSS AND EFFECT

An abnormal loss of condensers on the furnaces often arises, and it is difficult to determine whether it is due to the condenser itself or to the character of the luting material used to close the space between the condenser and retort, or to the carelessness of the men in handling the condensers. As a rule, however, the loss is held to about one condenser per day to every 11.5 retorts in the furnace. Assuming a 4000-retort plant the condenser loss would be about 350 per day, which at 4c. apiece would mean \$14 or 12c. per ton on the basis of treating 120 tons of green ore per day.

LOSS DUE TO EFFECT ON ZINC RECOVERY

The test of Table VI was made with a view of ascertaining this loss.

TABLE VI

No. of Condensers Changed	Total Weight, Lb.	Av. Weight Per Condenser
8	170	21
8	187	23
10	246	24.6
10	272	27.2
9	276	30.6
10	277	27.7
10	272	27.2
9	284	28.4
9	238	26.4
10	280	28.0
Total.....	94	2512
Average weight for condenser, 26.72 lb.		

After weighing the condensers the scales were set at the average weight, and every one of the ninety-four most nearly approaching this weight was set aside for a sample. In this way nine condensers were obtained. They were broken up fine, quartered, sampled and assayed, showing 35.5 per cent zinc.

Then $2512 \times 0.355 = 891.76 = \text{lb. zinc in 94 condensers}$, and $891.76 \div 94 = 9.487 = \text{lb. zinc in 1 condenser}$. If we again assume a 4000-retort plant changing 350 condensers per day we have $350 \times 9.487 = 3320 \text{ lb. zinc in condensers}$. If in retreating this material we lose 10 per cent our loss would be 332 lb. of zinc per day, or \$16.60, with spelter at 5 cents per 100 lb., or about 14 cents per ton of green ore. The total loss from condensers would therefore be 12 cents + 14 cents = 26 cents per ton of green ore.

FURNACE MUD

In addition to making the retorts and condensers, the pottery department is required to pug the furnace mud and make any miscellaneous tiles used around the plant, but as a rule the tile for the furnace lining is purchased. The furnace mud is used for stamping up or closing any openings between the retorts or about the furnace in general. The mud is made as cheap as possible consistent with the purpose for which it is used. It should be made rather lean so that it will not burn too hard, making it difficult to cut out.

It is well to know the following facts with respect to the pottery:

Weight of ground clay per cu. ft.
Weight of ground adobes per cu. ft.
Weight of green retort.
Weight of dried retort.
Weight of burnt retort.
Weight of clay in retort.
Weight of adobes in retort.
Weight of clay in condenser.
Weight of adobes in condenser.
Shrinkage of retorts and condensers in drying.
Shrinkage of retorts and condensers in burning.

POTTERY COSTS

The comparisons in Tables VII, VIII, IX, X, taken from two natural gas-field plants, and two coal-field

plants, give a fair representation of the labor cost of a pottery. As the condensers are nearly always made by contract they will not be considered.

TABLE VII—GAS-FIELD PLANT MAKING COMMON RETORTS

	Per Day of 9 Hours
1 Foreman	\$2.50
1 Retort man	1.75
1 Retort feeder	1.60
1 Retort setter	1.50
1 Pug mill men, @ \$1.70	3.40
2 Pug mill men, @ \$1.60	3.20
1 Mud piler	1.50
1 Crusher man	1.50
1 Wheeler	1.50
1 Retort trammer	1.60
12	\$20.05

TABLE VIII—COAL-FIELD PLANT MAKING HYDRAULIC RETORTS

	Per Day of 9 Hours
1 Foreman	\$3.00
1 Press man	2.00
1 Hammer man	1.90
1 Trimmer	1.80
1 Setter	1.75
1st Pug mill man	2.00
2nd Pug mill man	1.85
2 Pug mill men, @ \$1.75	3.50
1 Crusher man	1.85
1 General man	1.75
11	\$21.40

TABLE IX—GAS-FIELD PLANT MAKING HYDRAULIC RETORTS

	Per Day of 9 Hours
1 Foreman	\$2.50
1 Press man	2.50
1 Schlagger	2.30
1 Pug mill man	1.75
1 Pug mill man	1.60
1 Pug mill man	1.50
1 Wheeler	1.50
3 Roustabouts, @ \$1.50	4.50
10	\$18.15

TABLE X—COAL-FIELD PLANT MAKING COMMON RETORTS

	Per Day of 9 Hours
1 Foreman	\$4.00
3 Pug mill men, @ \$1.90	5.70
1 Retort maker	2.00
1 Retort setter	1.80
1 Finisher	1.80
1 Crusher man	1.80
1 Wheeler	1.80
1 Trammer	1.80
1 Laborer	1.75
11	\$22.45*

*Afterwards reduced somewhat.

It will be seen that eleven men and \$20 per day are required to carry on the operations of a pottery with respect to the fabrication of the retorts and that the cost per retort depends upon the number of good ones that can be put through the press in nine hours' time. It is due principally to this fact that in the past the cost of the hydraulic retort has been somewhat higher than the common. This difference, however, is being reduced from time to time.

The items making up the 50 cents per retort based upon using 60 parts of clay to 70 parts of adobes are about as follows:

Clay	\$0.0657
Adobes	0.1220
Supplies	0.0440
Labor	0.2526
Total	\$0.4843

Henryetta, Okla.

Chile as a Field for Manufacturing and Investment.—In order to acquaint our business men with the industries of Chile and to explain opportunities that exist there, a lecture was given by Hon. Senor Jose A. del Campo, commercial delegate of the Chilean Government and Consul of Chile, in Mobile, Ala., at the Waldorf-Astoria on March 29. The lecture was given under the auspices of the National Association of Manufacturers.

The Relation of Research to Everyday Life*

By Dr. J. B. Weems

Chief Chemist, Department of Agriculture of Virginia.

The investigator upon any problem connected with science is like the pioneer in a new country. Unseen obstacles may be met without warning at every point, and it is only those who have determination and who will make the sacrifice reach the goal.

Research may be defined as a diligent inquiry or a search after a desired object. In order that research may be of value those engaged in the work must be well equipped and the conditions made favorable to success. The conditions which will encourage research are well worthy of the most careful study on the part of those interested in the advancement of education and knowledge.

It will be recognized that those fitted for research are born with certain characteristics and this birthright brings to them an inherent ideal for the work. The heritage does not, however, carry with it the ability to seek out the unknown in the absence of the proper training. Both the heritage and the training of the faculties must go hand in hand to insure success.

The late President Gilman of the Johns Hopkins University tells us in discussing the characteristics of a university that, "Nobody can tell how it comes to pass that men of extraordinary minds are born of commonplace parentage and bred in schools of adversity away from books and masters. Institutions are not essential to their education. But every one who observes in a series of years the advancement of men of talents, as distinguished from men of genius, must believe that the fostering diet of the university—its 'plain living and high thinking'—favors the growth of scholars, investigators, reasoners, statesmen of enduring reputation, poets and discoverers. Such men are rarely produced in the freedom of the wilderness, in the publicity of travel or of trade, or in the seclusion of private life; they are not the natural product of libraries and museums, when these stand apart from universities, they are rarely produced by schools of the lower grade."

One of the necessary conditions which favors success in research is that one who undertakes this chosen field of labor must be a learned man, equipped and trained in order that he may be master of his special field of work.

It is naturally required that he know the past history of what has been done as related to his subject, and with this as a foundation a knowledge of what is being accomplished in associated fields at the present, he can select with judgment a field of work which in due season will yield results of value for the future years.

In these days when each field of knowledge is so vast that only a part can be mastered by any individual, there is a very strong tendency indeed for the average person to become restless and desire to enter at once into the work of research without the necessary equipment or training.

This necessary training and understanding as a preparation for research is only realized by those closely connected with scientific work. The general conception of scientific investigation has been well stated by Wells in his lecture on "The Discovery of the Future," delivered before the Royal Institution, as follows: "The popular idea of scientific investigation is a vehement, aimless collection of little facts, collected as a bower bird collects shells and pebbles in methodical little rows, and out of this process, in some manner unknown to the popular mind, certain conjuring tricks—the celebrated 'wonders of science'—in a sort of accidental way emerge.

*An address before The Virginia Chemists Club, Richmond, Va.

The popular conception of all discovery is accident. But you will know that the essential thing in the scientific process is not the collection of facts, but the analysis of facts. Facts are the raw material and not the substance of science. It is analysis that has given us all ordered knowledge, and you know that the aim and the test and the justification of the scientific process is not a remarkable conjuring trick, but prophecy."

The term popular is applied to anything intended for presentation to the general mass of our neighbors, who we sometimes forget have not had the opportunity of becoming familiar to any extent with science. It is true that the public have from time to time the privilege of hearing a course of lectures on scientific subjects in a popular manner and naturally it is very difficult to realize that they should have anything else but a very vague idea of science. The scientific man too often neglects the opportunity of presenting to the public the results of his labors. Many times this presentation of science is left to a select few of the order of Squeers, as created by Dickens in "Nicholas Nickleby." "Measles, rheumatics, hooping cough, fevers, agers, and lumbagers," said Mr. Squeers, "is all philosophy together; that's what it is. The heavenly bodies is philosophy and the earthly bodies is philosophy. If there is a screw loose in a heavenly body, that's philosophy; if there is a screw loose in a earthly body, that is philosophy, too; or it may be that some times there's a little metaphysics in it, but that's not often. Philosophy is the chap for me. If a parent asks a question in the classical, commercial or mathematical line, says I, gravely, 'Why, sir, in the first place, are you a philosopher?' 'No, Mr. Squeers,' he says, 'I ain't.' 'Then, sir,' says I, 'I am sorry for you, for I sha'n't be able to explain it.' Naturally, the parent goes away and wishes he was a philosopher, and, equally naturally, thinks I am one."

Much of the so-called popular science that is given to the masses has little science connected with it. As Le Bon states in speaking of the psychology of the crowd, "Affirmation pure and simple, kept free of all reasoning and all proof, is one of the surest means of making an idea enter the minds of crowds. The conciser an affirmation is, the more destitute of every appearance of proof or demonstration, the more weight it carries."

"Science as she is taught" might make a very interesting subject for investigation in its effects upon the popular mind. The result would give us some interesting psychological data, to say the least. It has been said of our schools: "Common schools is a splendid term, common is a splendid word, but there is such a thing as commonplace." Is not the science that the public gets commonplace?

Then again we have that peculiar phase of education that is of the nature of a tea party or along the lines of least resistance. As Mr. Dooley has said in his characteristic manner in speaking of the student's entrance on his college career: "Th' president takes him into a Turkish room, gives him a cigareet an' says: 'Me dear boy, what special branch ov learning wud ye like to have studied I'r ye be our compitint professors?'"

From the popular view of the young student the word research has something of wonder in it like unto that of the mystery of the olden times of the alchemist or the wonderful philosopher's stone which had the power to change the baser metals to the rarer ones of gold and silver. The word research is the mysterious key word to open the hidden treasures.

The memory brings before me the application of a very young student who wanted to enter college and take up research in chemistry. When asked as to his course of study it was stated that he had studied chemistry for six months and that in addition he had charge of the

store room at the school at the same time. On further questioning as to the book used for instruction, the title or the author of the book that had been used as a textbook could not be stated by the student, and as a last resort the statement was made that it "was a green book."

The student is not entirely responsible for this condition, but many who should know better mislead him too often. With the faith that is characteristic of the pupil in his teacher, he receives a very visionary idea of research, as may be shown from some of the recommendations given to students. The following may illustrate the manner in which some recommendations are given under such conditions:

"His particular work, aside from analytical work, has been the care and conduct of the State Food Exhibit, and he has done good research work in the taking of ice-cream samples, which has been of great value to the department."

The next consideration of interest in connection with research is that of the chemist and his personality. In this relation we have two views presented to us, that of the university, and that of the practical field of work.

In the university the atmosphere or spirit of the institution is in a large measure a determining factor in the grade of research work. The president of the institution controls to a great extent the conditions that may be present.

It has been stated by President Thring that "The college president cannot be one who produces original work in the college, as his position is that of an executive, but it is within his sphere to recognize the ability of those engaged in research work in the institution, and to see that proper conditions are supplied for this part of the advancement of education. It is well recognized that buildings, while necessary, do not make the college or university, and complicated apparatus may require so much care that there is little time that remains for other work. Even well planned buildings and a splendid equipment of apparatus do not insure the production of a high grade of research. Men are the essential feature in this special sphere of education."

It has been told of Agassiz that when asked why he did not make use of his ability to make money, he replied that he did not have the time for making money. If this ideal is held in an institution it becomes a responsibility on part of the public interested in the institution that the salary attached to the position is such that the problem of making both ends meet is not a difficult one. The plain living and high thinking may be advantageous under certain conditions, but sometimes the plain living is very much plain and very little living, and as a result there is very little high thinking. In other words, a man cannot devote his energies to high thinking if the funds for paying the bills for ordinary living are lacking.

A normal, well nourished boy is necessary as well as a well equipped mind for the production of a normal result. Can an investigator with a body that does not receive proper nourishment, under a nervous tension from unpaid bills and matters of a similar nature, carry out a piece of research work? It has no doubt been done again and again, but only by not meeting the obligations of life in a business manner.

In this connection the question may be asked, Is there not a responsibility to the public in connection with the field selected for research? Has the investigator the right to select a subject that is largely a matter of personal interest, or a hobby, if you please, and spend his time as well as the time of his students on such a subject, resulting in publication after publication of interest to only a select few or to only a very small group at

least? It is well to bear in mind that only a select few of these students can spend their lives on research and that to them the study is a bread and butter problem as well as their interest in the work as an equipment for educational training.

There is no doubt that the field of research in practical lines will give splendid results. We have not had the co-operation which should exist between the practical business man and the scientific investigator. One has regarded the other as a visionary impractical person incapable of business capacity, and the other has regarded the first as simply a dollar grasper, one who even dreamed of dollars and the methods of getting them. The fact of the case is that both are to a certain extent right and both wrong to a certain extent. The practical business man needs more scientific knowledge about his factories and the scientific man can learn much from the business man and a little knowledge of business methods, and incidentally a few more dollars will broaden his horizon rather than narrow it.

We need more followers in the steps of Liebig. Those who can undertake a scientific investigation and at the same time show a thoroughly scientific interest in the welfare of the masses. Liebig had this faculty, as may be shown by his wide knowledge and investigations in many lines and at the same time having time and interest to write his "Familiar Letters on Chemistry." It is said that the results of his work of this nature are seen in the present intelligent attitude of the German "practical man" to science, which has contrasted so strangely with that of his English brother for many years past.

We hear many complaints of the confining hours of the laboratory in the present day, but when we are told that in Liebig's laboratory "work went on from day-break till nightfall. There was no amusement and no dissipation to be had in Glessen, and the only complaint, which was a frequent one, was that of Auhel (the laboratory man), who could not get the workers to depart in the evening when he wanted to clean the room."

Liebig left to Germany a heritage in chemistry, and this she has developed in a wonderful manner. Let us listen to the message from Maximilian Toch as given in *Science* recently: "Many a chapter has been written on the regeneration of Germany. Where once barren fields stood, so barren that foodstuffs would not grow, there has risen vast works, bristling with vast stacks of factories and thousands of commercial flowers grow where once not even a weed would flourish. And in all of these plants chemists are working, controlling the products that are made and creating new things, and for every new and useful compound more work is found. Whereas 30 to 50 years ago, its best people left it like rats from a sinking ship, to-day many are immigrating, for it is a flourishing land, which chemistry has retrieved. Germany was always poor up to 10 or 15 years ago (written in 1909). With two or three possible exceptions no vast industries existed, and it had nothing to export, but to-day its exports are enormous, its people prosperous, in comparison with its neighbor, Austria, where industry is making slow progress."

Since the above was written we have seen as the result of the war how great an influence the chemical industries of Germany have had on the industries of other countries. Contrast with England, if you please, where the science of chemistry has been given little or no encouragement. Has America inherited its dilatory habits for the encouragement of chemistry from England? It is a question well worth our consideration, and if possible let America awaken to this fact before we have the experience which has been so ably stated by Prof. Armstrong recently in the *London Times*, as shown by the following extract from *Science*, July 23, 1915:

"Though I have fifty years' experience as a chemist, particularly in connection with the materials now being used in the manufacture of explosives and of natural and artificial organic products, I have never been consulted; and the only request for my assistance that I have received, since the outbreak of the war, came from a German gentleman, long since naturalized as a British subject. No doubt I am properly regarded as merely a retired professor, but I know highly competent younger men among those trained by me who are equally unutilized.

"Sir Joseph Larmor pointed out in your issue of March 29 that the country has no use for chemists. Yet we read in the daily papers that the chemist is the people's darling in Germany, and that the war is a war of chemists. We know that it will be in industry when the fighting is over. But in a country which is dominated by the lawyer-politician, in which, to use Matthew Arnold's expression, the idea of science is unknown, it cannot well be otherwise. We shall continue to muddle along, having reformed Oxford; we have changed our school masters and the idea of science is abroad: it is perhaps fortunate that it is fast being hammered into us by the high explosive shell."

In conclusion let us consider some of the needs of our country: (1) We need a great awakening as to the possibilities of chemistry in our industries and a realization on the part of the business man of what the science can do for the developing of the country. (2) We want a great awakening on part of the scientific investigator as to the great possibilities of the application of chemistry to the industries and the great field for the application of research. (3) We want a great awakening as to the value of men of character and training in the industries, not slaves of the test tube, but men with the ability to direct and control the industries along scientific lines. (4) We want a great awakening to the fact that we have been paying too much attention to dividends based on the dollars and not on the future development of our country. We have prided ourselves on how cheaply we produced regardless of how we ground the men. We have placed the chemist on par with the laborer and have not appreciated the training necessary for the proper work of the chemist. We have tried, not to get the best trained men, but how cheap we could get them. (5) We want a great awakening among the wealthy men in order to realize the value of institutions for practical research work like that of the Mellen Institute at Pittsburgh. Every State could use such an institution to its utmost capacity in developing its industries. (6) We want a great awakening for a square deal for the chemist and an opportunity for him to show what can be done for the country. This means fair returns for his labor, an appreciation of his value to society, and a chance to take his place as a business man in the business management of the industries.

Will the sleeping giant which we call "the business world" awake to the opportunity before him or will he sleep on to his destruction and the loss of the chance to make the most of the country? This is the question.

Richmond, Va.

The *Kwagaku Kogei* or *The Chemical Technology*, is the title of a new Japanese journal edited by Prof. Dr. H. Nishida. The first issue appeared in January, 1917. There are 106 pages of text, of which four are printed in English (reproduced on pages 505 and 506 of our present issue) and 102 in Japanese; among the illustrations in the latter we recognize the coal-tar tree and a portrait of Dr. Baekeland. There are 24 pages of advertisements. We extend our best wishes for success to this first Japanese chemical journal.

Spring Meeting of the American Chemical Society at Kansas City, Mo.

The meeting held by the American Chemical Society from April 10 to 14 in Kansas City, Mo., with headquarters at the Hotel Muehlebach, might well be termed a preparedness meeting. If it is considered that this meeting came near being called off by the president of the society, the attendance was remarkable, numbering approximately 400. The meeting place for the gathering of so many chemists was very fortunately chosen as it gave an opportunity for the members from other parts of the Union to see the possibilities of the great Middle West, of which Kansas City may well be called the center and the resources of which will be mentioned later.

The country is at present facing a crisis. The minds of the people in general are on edge. At no time, since the founding of national engineering and scientific societies, has it been of such paramount importance to hold meetings and give exhibits as now, for it is a necessity to bring before the public the natural, the intellectual and the commercial resources of the nation. Nothing eases the mind so much as to know that in an emergency of this kind the natural and industrial resources are in adequate shape of being utilized to guarantee the safety of the nation.

The meeting was officially opened on Tuesday, April 10, at 6.30 p. m., by a banquet tendered to the Council of the society at the University Club. Wednesday was opened with a general meeting, followed in the afternoon by a public session on Petroleum and Natural Gas. Thursday morning was devoted to a Symposium on the Chemistry and Metallurgy of Zinc. The rest of the time was taken up by the reading of the various

papers before the individual divisions and by trips around the city and to neighboring industrial and metallurgical plants of interest. The number of papers read before the society was 136. They were distributed as follows:

Public Session on Petroleum and Natural Gas.....	7
Symposium on the Chemistry and Metallurgy of Zinc.....	8
Industrial Chemistry and Chemical Engineering.....	14
Physical and Inorganic Chemistry.....	22
Organic Chemistry.....	19
Agricultural and Food Chemistry.....	15
Biological Chemistry.....	33
Water, Sewage and Sanitation.....	5
Pharmaceutical Chemistry.....	13
Total.....	136

Few if any criticisms can be made regarding this meeting, but two suggestions are certainly in place. First of all, it is absolutely essential that the papers offered before the meeting should be in the hands of the members at least a month before the meeting takes place. This is a necessity, as only through the knowledge of the subject treated is a satisfactory discussion possible, and after all the discussion is vital for the production of new thoughts and ideas. With the vast number of papers and subjects offered at such a meeting it is essential, that each member know before hand what he wishes to hear and to discuss. That can only be accomplished satisfactorily by giving into the hands of the members the original papers or at least abstracts of the papers previous to the meeting. Under present conditions the general trend of discussions was rather slow and lacked animation.

The second suggestion is that, especially in times as the present, there should be exhibits of local products



PHOTOGRAPH TAKEN AT BANQUET OF AMERICAN CHEMICAL SOCIETY AT KANSAS CITY

or products from the near vicinity. It is of interest to know what the locality can furnish in time of need. Exhibits of the oil refineries, the electrolytic galvanizing plant, packing houses, paper mills, soap factories and many other concerns would have more clearly enlightened the possibilities of the district than any number of papers could have done. Let people actually see the crude materials and the finished products from any certain section of the country where national meetings are held.

The Council Meeting

In a preliminary council meeting PROF. W. A. WHITAKER suggested a special division on metallurgy to be incorporated in the society. Unfortunately this recommendation was not passed.

The resolutions taken and passed in the regular council meeting were: that a committee be appointed to deal with the co-operation of the industries and universities. At the suggestion of DR. W. F. HILLEBRAND a committee was appointed to insure greater purity of reagents necessary in chemistry and in the industries. Local sections and divisions have no authority to publish or issue any resolutions or official actions on matters of national importance. A committee comprising the president, the secretary, the two most recent past presidents and two councillors at large were appointed to act for and on behalf of the American Chemical Society in matters of national importance. It was also resolved that a plea be made to the ladies of the nation to refrain from buying jewelry set in platinum, and that platinum should not be used in photography. This action was taken to conserve this valuable metal for more stringent uses during the state of war, as the supply in this metal is very low in the United States.

The next meeting of the society will be held at Boston, Mass., in the week opening Sept. 10, 1917. Invitations from Philadelphia and Cleveland were received for the spring meeting in 1918, but no action was taken on the matter.

Opening Meeting

The Wednesday morning meeting was opened by Prof. W. A. WHITAKER, who mentioned in his speech the potential importance of Kansas City along the line of chemical industries. The representative of the Mayor of Kansas City followed with some statistics regarding the city. Kansas City is first in the manufacture of Pullman cars, handling of hay, yellow pine and farming materials; second in handling meat products, grain, live stock and mules; third in lumber, flour and the poultry trade; fifth in banking and seventeenth in population. It is interesting to know that eighteen trunk lines enter the city and that 260 passenger and 1500 freight trains pass through Kansas City per day. The city also has 70 miles of boulevards and parks. Without any doubt Kansas City is one of the greatest centers of production in the Middle West.

Dr. F. STRONG, chancellor of the University of Kansas, then made the welcome address. In a very interesting manner Chancellor Strong brought to the attention of the members the possible effect of the war on the universities and colleges of this country. Had we not entered this war, the speaker claimed, the United States of America would have led the nations in universities and colleges. If, on the other hand, this war lasts any length of time, it will take ten to twenty years to get back to our present standing. Hope was also expressed that the food situation may be regulated. A great and important sentiment in true Kansas progressiveness was voiced by Chancellor Strong when he expressed the hope after this war all party politics be eliminated

and this nation have a national government, the state governments to be abolished as ineffective and wasteful. From the applause the speaker received it may be judged that many of those present agreed with him on the subject.

Dr. JULIUS STIEGLITZ, president of the American Chemical Society, accepted the proffered hospitality on behalf of the society. He briefly stated the duty of the society to the country and elaborated on what the individual could do. The latter should offer the best that is in him. For the successful termination of the war as far as the United States is concerned, it is necessary that all preparations be conducted on a scientific basis and that brains be saved at the sacrifice of brawn. The chemist is a necessity to the country, and he is of more value alive than dead.

ARTHUR J. BOYNTON then read a paper entitled: **The Economic Resources of the Kansas City Zone.** This zone involves Kansas, Oklahoma, and Missouri. The whole zone grew up, as one might say, with Kansas City. As a railroad center Kansas City is second only to Chicago. It is the center of the Southwestern oil and zinc fields. Agriculturally it is one of the big centers of the United States. Kansas City is the center of the tenth national bank district. The natural gas

TABLE I—PAPER OF ALLE: A D LYTEN

Location	(1)	CO ₂	HHC	O ₂	CH ₄	C ₂ H ₆	Res.	B.L.U.
Augusta, Kan.	0.13	0.00	0.00	10.54	1.64	87.69	129	
Cowley Co., Kan.	0.13	0.00	0.37	16.27	3.01	80.23	209	
Chautauqua Co., Kan.	0.30	0.00	0.18	42.38	1.85	55.29	441	
Chautauqua Co., Kan.	0.00	0.00	0.40	49.01	3.89	46.67	541	
Ellsworth, Kan.	0.30	0.23	0.00	61.00	1.09	37.20	609	
Ponca City, Okla.	0.05	0.00	0.40	41.60	14.86	40.10	688	
Kay Co., Okla.	0.21	0.32	0.00	57.91	9.89	31.65	735	
Chautauqua Co., Kan.	0.55	0.00	0.81	85.53	0.15	12.95	839	
Chautauqua Co., Kan.	0.11	0.50	0.08	79.13	7.79	11.39	894	
Bufler Co., Kan.	0.00	0.71	0.14	62.15	18.38	18.64	930	
Montgomery Co., Kan.	0.24	0.24	0.25	83.04	8.54	7.95	970	
Blackwell, Okla.	0.00	1.18	0.16	70.69	18.65	9.32	1025	
Cushing, Okla.	Tr.	0.12	Tr.	70.74	21.64	7.49	1059	
Bartlesville, Okla.	0.24	1.21	0.24	70.50	21.60	3.21	1125	

TABLE II—OKLAHOMA GASES

Pawhuska	3	0.77	0.15	0.62	90.90	5.40	2.40	971
Cushing	5	Tr.	0.12	Tr.	70.74	21.64	7.49	1059
Cushing	2	0.83	0.42	0.47	67.26	18.96	12.14	984
Bighorn	3	0.86	0.15	0.30	75.90	16.43	3.34	1048
Hamiy Creek	2	0.16	0.46	1.07	79.09	11.47	7.76	970
Hamiy	2	Tr.	0.00	Tr.	75.65	8.69	15.52	881
Bartlesville	7	0.13	1.03	0.39	72.02	21.18	5.29	1078
Hogshooter	5	0.14	0.83	0.10	67.36	20.43	8.23	1075
Hogshooter	2	1.55	0.00	0.39	91.22	2.35	3.98	927
North Osage	8	0.40	0.80	0.54	72.64	13.62	11.88	950
Wann	4	0.48	0.49	0.32	76.66	16.25	5.80	1028
Wagner County	1	1.60	1.53	0.06	69.01	17.31	10.17	951
Blackwell	14	0.00	0.32	0.47	71.40	20.13	7.76	1043
Blackwell	1	0.95	0.10	0.11	60.54	6.22	32.97	690
Ponca	5	1.00	0.23	0.60	81.16	7.53	7.08	947
Ponca	1	0.05	0.01	0.40	44.09	14.98	49.10	688

TABLE III—KANSAS GASES

Augusta	32	0.00	0.71	0.14	62.15	18.38	18.64	930
Sedan	13	0.00	0.00	0.40	49.01	3.89	46.67	541
Sedan	6	0.30	0.00	0.18	42.38	1.85	55.29	441
Arkansas City	2	0.00	0.38	0.10	67.36	14.68	17.46	908
Arkansas City	1	0.00	0.43	0.00	73.28	17.10	9.18	1006
Allen County	1	0.35	1.15	0.39	79.80	4.33	14.00	865
Winfield	5	0.36	0.00	0.24	77.90	9.51	11.98	912
Havana	2	0.00	0.45	0.00	67.36	13.46	13.34	935
Benedict	1	0.12	0.00	0.46	92.30	—	4.30	900
Ellsworth	3	0.33	—	0.15	60.43	3.41	35.77	639
Winfield	7	—	0.37	0.12	76.24	20.32	12.72	920
Chautauq	7	0.73	0.24	0.02	90.36	2.91	5.22	932
Frederia	10	0.67	0.24	0.31	91.40	2.41	4.96	924
Humboldt	6	0.72	0.49	0.24	92.92	2.52	3.11	944
Neodesha	4	0.73	0.24	0.24	81.86	6.88	7.02	943

(1)—No. of samples.

No. 8 from 330-foot sand; No. 9 from 580-foot sand.

All B.L.U. above are calculated to 67° C. and 760 mm. pressure from the following values: Heavy hydrocarbons (HHC), 1627; CH₄, 986; C₂H₆, 1728.

AUGUSTA FIELD

Shallow gas	—	0.13	0.00	0.00	10.54	1.64	87.69	129
Varner No. 2	1	0.09	0.27	0.00	44.63	9.49	45.50	599
Wilson No. 1	2	0.07	0.19	0.19	63.92	5.67	39.96	719
Carter No. 1	2	0.00	0.00	0.00	60.10	9.53	30.36	745
Foster No. 3	4	0.00	0.00	0.50	49.60	21.31	28.59	847
Moyle No. 1	2	0.29	0.33	0.29	67.67	15.25	14.16	942
Love No. 1	—	0.13	0.13	0.00	71.61	18.72	9.37	1015
Varner No. 2	—	—	—	0.00	75.54	20.00	4.45	—



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resources offer the zone a cheap fuel and permit such industries as zinc, cement and glass to prosper on a large scale. Other industries of interest are: the gypsum industry, gypsum being used for paint, plaster and cement; the salt industry, both rock salt and brine being handled in the ten plants now in operation. Finally clay products play an important role in this zone. Undoubtedly few of those present realized the importance and one was impressed by the remarkable activity of the district. Besides the many industrial plants, such as refineries, soap factories, tanneries, etc., one factor leading to success must be mentioned, namely, the co-operation of the railroads with the district. This is a fine example to certain Western cities which are suffering in their development due to the lack of said co-operation.

Public Session on Petroleum and Natural Gas

Wednesday afternoon was devoted to a public meeting on petroleum and natural gas. Dr. H. P. CADY was chairman.

The first paper presented was by RAYMOND C. MOORE on *The Geology of the Mid-Continental Oil and Gas Fields*. This was briefly discussed.

The second paper, *Variations in the Composition of Gases of the Mid-Continental Oil and Gas Fields*, was presented by H. C. ALLEN and E. E. LYDER. This comprised mainly the results obtained in connection with the determination of the fuel value of said gases and oils. As the composition of these gases and oils is of considerable interest, the figures in the paper are reproduced in Tables I to III.

Helium and Associated Elements in Kansas Natural Gases was the title of a paper offered by C. W. SEIBEL. It is of interest to note that the gases from the Augusta fields carry as high as 1.97 per cent helium. This rare gas is the one occurring in the largest amounts, all the others being present in mere traces. Dr. R. B. MOORE suggested the use of such amounts of helium from a large gas supply for the filling of balloons if it were possible to extract it in an economic manner. Dr. H. P. CADY replied by stating that there would be no difficulty encountered in its extraction on a large scale.

Another interesting paper was that by E. P. FISHER, *Some Experiences in the Use of Oxy-Acetylene Welding in Long Distance Natural Gas Transportation*. Mr. Fisher gave a very interesting description of the process used in all of the lines of transportation for gases in the district. It differs from most other lines in that there are no joints or knees used throughout

the system, all connections being made with the aid of the oxy-acetylene blow pipe. Many difficulties had to be overcome, such as, for instance, the time, condition and the type of laborer best suited for the work. It was decided to work in squads termed doubles, quads and eights. The doubles are those which weld two pipe lengths together, the quads weld two doubles and the eights weld two quads together. The most suitable type of labor was found to be the Bulgarian as, according to the author, some intelligence is required to do the welding satisfactorily. The paper was enlivened by a motion picture showing the various steps in manipulation.

Due to the length of time required for showing the pictures in the preceding paper, the last three papers had to be cut short. Dr. ROY CROSS presented a paper entitled *The Cracking of Petroleum in the Liquid State*. The writer stated that initially the temperature-pressure relation underlies the cracking of the petroleum. He demonstrated by curves the difference in the cracking of petroleum in the liquid and the gaseous state. Furthermore, the paper referred to the importance of the ratio of specific gravity to boiling point. If this ratio is low in a gasoline the latter is of a good quality.

WALTER F. RITTMAN'S paper, *One Billion Gallons of Synthetic Gasoline in 1918*, was read by GUSTAV EGLOFF. Five methods for cracking oils will be available for the production of gasoline. Cracking in the liquid state, cracking in the gaseous state, cracking in the presence of a catalytic agent, cracking by the use of oil and steam, and finally cracking by a combination of all the mentioned methods. The gasoline demand will rise proportionally to the number of automobiles used. One-fifth of all the gasoline produced in 1917 will be made by means of the cracking process. It is anticipated that 1,000,000,000 gal. of gasoline will be produced by one or the other of the cracking processes in 1918.

Dr. Egloff in his addenda to this paper showed the possibilities of producing benzene and trinitro-toluene by cracking and re-cracking. This is entirely feasible if the gas standard is changed from an illuminating to a heating standard. If this is done \$25,000,000 may be saved annually in form of benzene, toluene and xylene.

The final paper of this session was rendered by HARRY H. HILL, *The Chemical work of the Petroleum Division of the Bureau of Mines*. Research is continually carried on by the department for the improvement of the products offered to the consumer. Petroleum, gasoline and other oil products are thus

investigated and analyzed as to their composition and properties. Investigations on the crackings obtained by the Rittman process are constantly conducted. Work on refining and establishing suitable standards is carried out by the bureau so as to prevent the market being flooded by unsuitable products.

Symposium on Zinc

The symposium on zinc covered the forenoon of the Thursday session, and was presided over by H. E. HOWE. The society is indebted to the endeavors of Dr. John Johnson, who was untiring in his work in preparing the symposium.

The first paper offered was a short one on **A New Method of Separating Zinc from Cadmium and the Determination of the Latter Iodometrically**, by ERIC J. ERICSON. Briefly it consists in crystallizing out the zinc from a zinc-ammonium sulphate solution, and then determining the cadmium by any of the well-known methods. The separation consists in crystallizing the zinc out as zinc sulphate or zinc-ammonium sulphate. It may be applied to the determination of cadmium in ore or in spelter (after removing and determining lead). In the latter case, although a small trace of cadmium is entrained in the crystals, only one crystallization is deemed necessary in view of the large sample taken. After removal of zinc, the cadmium may be determined by any of the usual methods. An iodometric method is outlined.

Determination of Cadmium in Brass by EDWARD SCHRAMM was the second paper offered. Small amounts of cadmium present in brass are exceedingly hard to determine. The method suggested by the author was first tried on known salt mixtures and then applied to commercial brasses. It consists of first partly freeing the nitric acid solution of copper by electrolysis, then precipitating out the rest of the copper, the tin and the lead by the ordinary method, then adding dilute sulphuric acid to the solution and getting the zinc and cadmium into the form of sulphates. The cadmium is then precipitated out by means of hydrogen bisulphide. The difference from the old method is in the precipitating out of the cadmium sulphide from a small volume of solution low in acidity. The cadmium sulphide after filtering is then converted into the sulphate by treating with sulphuric acid and reprecipitated as the sulphide by using ammonium polysulphide according to Noyes' method.

Mr. Schramm also read the third paper, the author of which was R. F. VON BICHOWSKY on **The Electrometric Determination of Zinc**. Three principal sources of error are encountered in the ordinary determination of zinc with potassium ferrocyanide. First oxidation of the ferrocyanide by any nitric acid, chlorine or bromine present; second, precipitation of other metals along with zinc; and third, uncertainty of the end point. To remove the first source of error, precautions such as the addition of SO_2 should be taken. To avoid the precipitation of other metals the rational procedure is to change the conditions of the ferrocyanide precipitation by carrying it out in solutions containing from 10 to 20 per cent HCl. In these solutions zinc ferrocyanide is only slightly soluble, but lead, manganese, iron, and copper ferrocyanides are very soluble.

Since the ordinary indicators cannot be used at this concentration of acid, an electrometric determination of the end point is adopted which is found to be quicker and more accurate than the older methods. This consists in noting the point at which there is a sharp change in potential of the solution against a platinum electrode. The apparatus is the same as that used in determining the end point of oxidation and reduction,

reactions in the analysis of iron, vanadium, chromium, etc.

Experiments on a number of salt mixtures show that the end point is not affected by the amount of acid or neutral salts present within reasonable limits nor by the presence of iron, lead, manganese (up to 50 mg.) or by small amounts of copper and cadmium. The preliminary operations for the purification of the ore therefore lose their customary importance; comparative results show that the electrometric method is more rapid than the usual procedure.

Apparatus for the performance of the analysis were shown on a screen, as well as curves illustrating the success with which the analysis may be conducted in solutions containing 15 or less per cent of free hydrochloric acid. In the discussion which followed it was brought out that this method gave satisfactory results on ores carrying large amounts of copper, and that the method was just as rapid as the one used at the present time in zinc smelters.

In the absence of the author, E. H. BUCHANAN, the paper entitled, **The Occurrence of Germanium in Missouri and Wisconsin Blendes**, was ready by Dr. John Johnson. In this paper the author gave a brief history on germanium, and mentioned the discovery of this element in some blendes from Wisconsin and Missouri. He came to the conclusion that it may be generally accepted that 0.01 per cent of the amount of germanium found in smelter residues would be the amount of the element found in the original ore. These blendes might be used as a source for this rare element if some use for the metal could be found.

Dr. W. F. HILLEBRAND then showed a sample of metallic gallium and suggested this metal for the use of thermometers between 300 and 1000 C. in place of mercury, as its boiling point is 1700 C. The sample shown was liquid, resembling mercury, but having only about half its weight. It was kept under dilute sulphuric acid to prevent its adhering to the glass of the bottle. Dr. Hillebrand suggested that this adhering might be due to impurities similarly as with mercury.

Dr. JOHN JOHNSON then offered his own paper, **The Vapor Pressure of Zinc and Related Metals**. The paper was a compilation of all the available data on the vapor tension of metals, which were then summarized in the form of curves. As these curves are of considerable interest they are reproduced in Fig. 1. The scale of abscissas at the top gives the vapor tensions p , the scale at the bottom their logarithms. The scale of ordinates at the right gives degrees Centigrade, the scale at the left 1000 times the reciprocal values of the absolute temperature.

A rather lively discussion followed this paper, conducted by J. T. Baker and Dr. S. Fischer, Jr. The latter mentioned some work carried out by him under Dr. Joseph W. Richards at Lehigh University on the vapor tension of metals below their melting point. Formulae were derived by which the vapor tension of any metal could be calculated for any temperature either in the liquid or the solid state. The plotting of the data indicated clearly the break in the vapor tension curve at the melting point of the metal in question.

The next paper on the program was entitled **The New Zinc Fields of Kansas-Oklahoma**, by P. HAYNES. The paper was illustrated by lantern slides. The present demand for zinc and its high value have caused a remarkable development in zinc mining and milling in the extreme southeastern part of Kansas and the adjoining northeastern part of Oklahoma. During the last six months many new towns and hundreds of mills have been built on the prairie lying to the southwest of the Galena-Joplin district. A visit to the new zinc fields

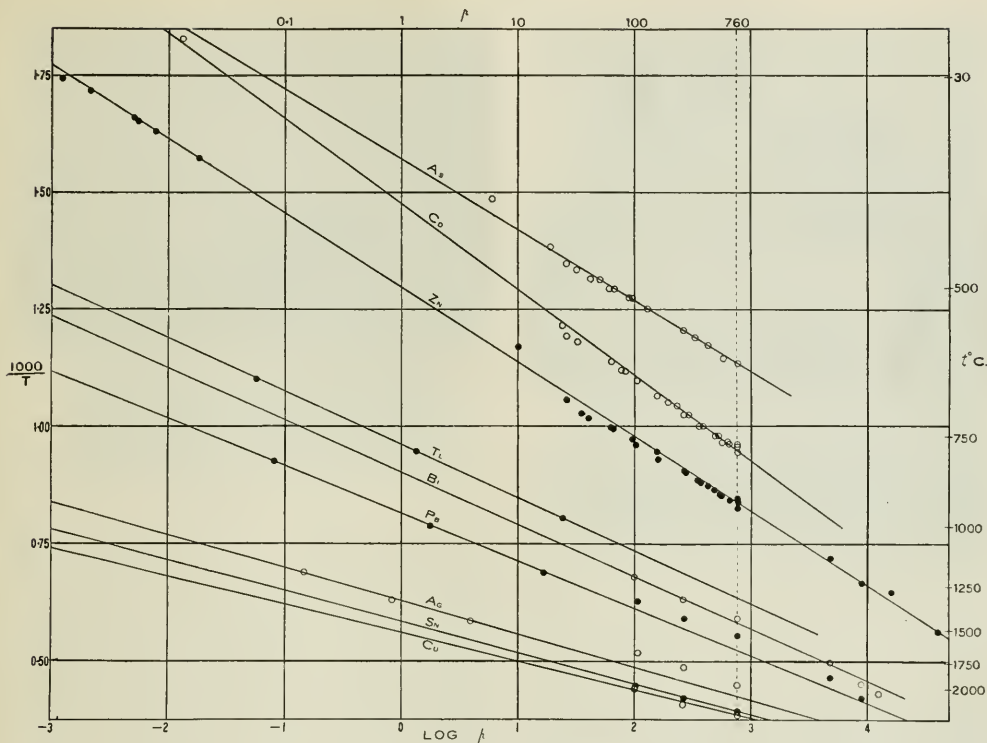


FIG. 1—VAPOR TENSION CURVES

south of Baxter Springs, Kan., and to Picher and Admiralty, Okla., shows the great strides in production which this district is making. Small drilling rigs dotting the prairie mark the advance guard prospecting to determine the value and extent of the ore bodies on each lease. Concentrating mills follow closely and give the appearance of a large city.

The ore minerals in this new district are chiefly sphalerite, with some galena and variable amounts of pyrite and marcasite. This ore is much richer than in the older Galena-Joplin district, and frequently contains over 20 per cent of sphalerite. The origin of the ores of this district is still somewhat in doubt, but the most recent researches by Siebenthal have led him to conclude that they have been produced from the disseminated sulphide minerals scattered through the Cambro-Ordovician limestones, by artesian waters transporting them in solution and ascending and depositing them in the open spaces of the cherty members (Grand Falls chert) of the Boone formations (Burlington or Mississippian limestone), which is the productive horizon in this region.

The paper by A. E. WELLS, Results of Recent Investigations on Smelter Smoke Problems, then followed. The dust and fume element it is claimed is not harmful to agriculture, but arsenic if present may harm live stock. On the other hand, it was indicated that amounts of arsenic present in smoke, sufficient to harm live stock, would be worth the saving by the smelter. Ways and means for the study of the effects of SO_2 on agriculture were then shown and explained. As a rule, wherever feasible the SO_2 should be converted into either sulphuric acid, liquid SO_2 , or sulphur. This conversion

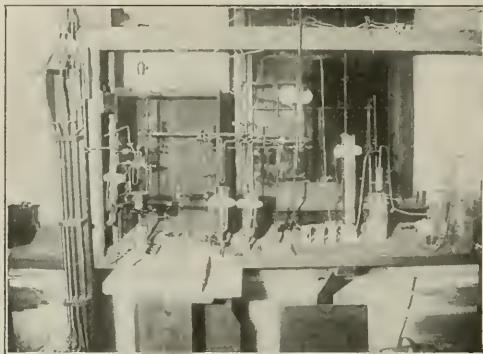
naturally depended on the market demand of the locality for these products. Curves illustrating the concentration of SO_2 at different distances from the stack were shown. Also the effect of increased height of chimney and increased temperature of the stack gas on the SO_2 concentration were illustrated by curves. High stacks and high temperature, it is claimed, are the best means to eliminate the danger due to SO_2 .

A paper by E. E. WATTS, on The Hydrometallurgical and Electrolytic Treatment of Zinc Ore, was read by title. It relates the writer's experimental work on the ore of the Sullivan mine at Kimberly, B. C. This work served to develop a process which involved sulphurous-acid leaching of the ore, and further experimental work developed the Watts process. By this process zinc oxide obtained by any suitable means is treated in specially constructed electrolytic tanks for the recovery of zinc. In conclusion the work done in the experimental plant of the Electro Zinc Company at Welland, Ont., is recorded.

Division of Industrial Chemistry and Chemical Engineering

The symposium on zinc actually was part of the elaborate program of the Division of Industrial Chemistry and Chemical Engineering. In the following we give abstracts of the other papers presented before this section.

The paper by O. R. SWEENEY and JAMES R. WITHROW dealt with the chemical examination of industrial brines. The value of chemical examination, from the manufacturer's standpoint, was discussed and a method was outlined. The errors resulting from improper sam-



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pling were shown, and a suggestion for a standard method was given. The constituents which it is thought should be determined were given. A standard procedure for determining the density was described and the best temperature to use discussed. Suggestions for determining total solids were made; the procedures for silica, iron and aluminum were given. Simplifications of the usual methods for calcium and magnesium in mineral water were described, also the procedure for barium, strontium, sodium, potassium and sulphuric acid. A modification of the bromine determination was described.

A paper by **FREDERICK DANNER** dealt with the industrial chemistry of chicle and chewing gum. The author presents methods for the valuation of commercial block chicle by determining moisture, viscosity, resins, proteins and carbohydrates and mineral matter. Twenty problems relating to the chewing-gum industry were presented. The total exports of finished chewing gum amounted in 1916 to \$574,400, equivalent to approximately 718,000 lb. This represents crude chicle equal to at least 179,000 lb. The amount of chicle imported, manufactured and consumed in the United States in 1916 was approximately 7,031,000 lb., equivalent to 28,124,000 lb. of chewing gum. The per capita consumption is roughly 3.5 lb. or 55 packages per annum. Researches are at present being carried out on the constituent elements of chicle—alpha chicle-alban; beta chicle-alban; gamma chicle-alban; chicle-fluavil and chicle-gutta. These substances have been investigated by Tschirsch and later by Bosz and Cohen. The latter investigators have not entirely agreed with the results published by Tschirsch.

A paper by **FREDERICK DANNER** dealt with the cultural and Mechanical College) described apparatus for determining the specific gravity of natural gas. The apparatus is to be used according to the method proposed by Bunsen, which is based on the fact that the specific gravities of two gases bear approximately the same ratios to each other as do the squares of their rate of flow when passing through a very small opening.

The apparatus consists of a pipette or burette to which is sealed at right angles, just below the tip, a glass stop cock. To the tip of the burette another stop cock is sealed which is provided with a very small, practically invisible opening. The gas to be examined is admitted through the larger side opening and the time of escape is measured in the same manner.

The method is illustrated by the following example: The time required for the sample of gas to escape was 13.4 seconds and for the same quantity of air 11.8 sec-

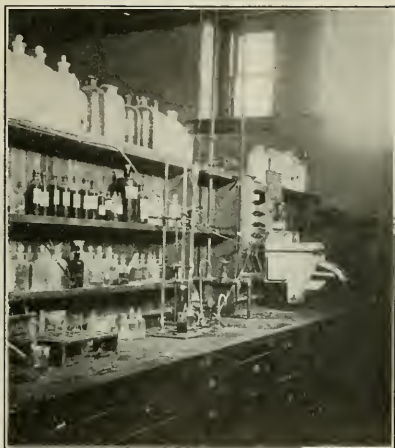
onds; these squared are equal to 150.4 and 129.9. As the specific gravity of natural gas is referred to air as unity, the specific gravity is obtained by dividing 129.9 by 179.5 = 0.723, the specific gravity of the gas.

A paper by **NIELS C. ORTVEA** discussed comparative results from experiments in the distillery with open and closed fermenters. A closed iron fermenter of the latest type with a capacity of 4000 liters was brought from Germany in 1914 and a wooden open tub of the same capacity was constructed. Eleven experiments were made, fermenting simultaneously mash from the same batch in both vessels. The results obtained were in favor of the closed fermenter, viz., lower acidity in the finished beer, and increased yield, amounting to 1 per cent of spirit. The yields from the open fermenter corresponded to the average yields obtained in the ordinary normal runs of the distillery.

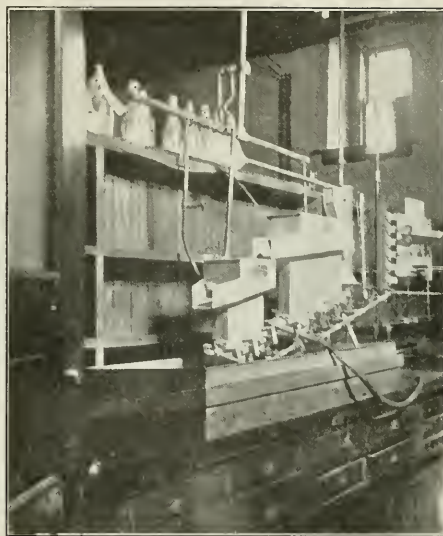
A paper by **CHARLES S. REEVE** and **RICHARD H. LEWIS** discussed the effects of exposure of some fluid bitumens. Exposure tests conducted for a period of one year show that certain types of petroleum harden materially while others are relatively little changed in their physical character, although all are materially changed in their composition as shown by the change in percentage of bitumen insoluble in naphtha and free and fixed carbon values. The relation between amounts volatilized upon heating for various periods in a laboratory oven at 163 deg. C. and the amounts lost upon atmospheric exposure were shown by tables, and relations between the characters of the residues obtained by the two methods of volatilization were given. As in previous work on the subject the changes which occur in bitumens upon exposure are notably greater than can be accounted for by mere loss of volatile constituents, and are due to chemical changes in the constitution of the bitumen itself.

There were two papers by **GUSTAV EGLOFF**. The first on benzene, toluene, and xylene from petroleum, is printed in full elsewhere in this journal. The second paper dealt with the formation of benzene and toluene by the action of aluminium chloride on solvent naphtha.

Solvent naphtha derived from the thermal decomposition of coal, having a specific gravity of 0.867/15.5 deg. C. and 93 per cent distilling between 135 deg. and 160 deg. C., with the dry point at 181 deg. C., was treated with anhydrous aluminium chloride. Five per cent by weight of $AlCl_3$ was added to 1 liter of solvent naphtha and distilled over in two hours from a Hempel flask until 78 per cent came over. The distillate was neutralized with caustic, washed and dried over calcium chloride. The distillate upon analysis gave on the basis



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FLOTATION WORK



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of solvent naphtha used 1.2 per cent of benzene and 13.9 per cent of toluene.

A paper by O. L. BARNEBEY discussed the determination of available oxygen in oxidized manganese ores. The oxalic acid method is the method in common use in America for the determination of available oxygen in oxidized manganese ores and hence is the basis for the evaluation of such ores for certain industrial purposes. This method gives inconsistent results, causing much difficulty in control work involving the use of pyrolusite and similar products. The method is shown to be highly empirical, the errors being produced by decomposition of the oxalic acid by the action of light in the presence of manganese salts. A modified ferrous sulphate method is accurate and is recommended for factory control work. The latter method gives results in close agreement with results obtained by Bunsen's distillation method and a new direct iodimetric method worked out by the author.

A paper by A. W. HIXSON and HAROLD E. HANDS discussed some relations of the effect of over-heating to certain physical and chemical properties of asphalts. The object of the research was: 1. Investigation of the extent to which an asphalt can be heated and still retain properties desirable for structural purposes. 2. To determine if "carbènes" are a result of overheating. 3. To determine the relation of carbene content to physical and chemical properties of asphalt. 4. To determine the value of the carbene specification for asphalts that are to be used for structural purposes.

An oil asphaltic cement, a brick filler fluxed with an asphaltic oil residuum and a crude Trinidad asphalt were heated to various temperatures between 163 deg. C. and 250 deg. C. under uniform conditions. Physical and chemical analyses were made on the products of the various heatings.

The results show that heating asphalts above certain temperatures changes both the physical and chemical properties. The carbene content was not changed materially until the temperature of heating was above 200 deg. C. Above that temperature there was a decided increase in carbènes. The results seem to indicate that carbènes are the result of cracking paraffine and asphaltic hydrocarbons into naphthenes and unsaturated hydrocarbons. Moderate heating may so change the nature of the asphalts as to render them

more soluble in carbon tetrachloride than in carbon disulphide. Overheating causes marked changes in natural and oil asphalts which render them unfit for many structural purposes. Two hundred and thirty-five deg. C. is probably the maximum temperature to which an asphalt may be heated without permanent injuries to its useful properties and for certain structural purposes they should not be heated above 200 deg. C. It is believed that the fixed carbon content when corrected to the original weight before heating offers a means of tracing the changes in the molecular structure of the hydrocarbons when they are subjected to the influence of heat.

There is a close relation between the carbene value and the physical and chemical properties of asphaltic materials. The carbene specification is important for asphaltic materials for construction purposes.

A paper by H. E. HOWE, of Arthur D. Little, Ltd., Montreal, Canada, discussed the chemical industry of Canada. Unfamiliarity with Canada, her industries, market and natural resources, has led many to consider that country a cold fringe on the North American continent, an excellent place for winter sports and fishing, but offering no opportunities for industry, especially chemical industry. Mr. Howe's paper outlined something of the chemical industry in Canada, with special reference to recent important developments and new processes which have been perfected under the stimulating influence of war conditions, but which will become important factors in the chemical business after the war. It also recounted something of the natural resources of Canada as indicating the raw materials upon which chemical processes and industries may eventually be based, and concluded with the statement of the steps that are being taken by private corporations, educational institutions and the Government to apply scientific and industrial research looking toward the more economic utilization of natural resources and the establishment of chemical industries to serve a population which will undoubtedly increase at an abnormal rate following the declaration of peace.



PLANT OF THE NATIONAL

A paper by D. A. RUSSELL described the chemical laboratory of the Youngstown Sheet & Tube Company at Youngstown, Ohio, which provides for the departments of metallurgy, chemistry and inspection. The construction of the building, arrangement of rooms and equipment were described, attention being called to special features.

A paper by H. W. GILLET and E. L. MACK on ferro-uranium first reviewed the information so far available and rather contradictory on the use of uranium steels as tool steel and ordnance steel on the production of ferro-uranium by former experimenters. The authors then described experiments of their own in which they used uranium oxide produced by the National Radium Institute. It was mainly UO_2 , with some U_3O_8 . The main results of the authors' experiments may be summed up as follows:

By using a pure UO_2 , a low-ash coke, and a pure iron as raw materials, with CaF_2 as slag former, and using a tilting electric direct-arc type furnace with water-cooled magnesite hearth and sides, it should be possible to produce commercially, without a second refining operation, ferro-uranium of any desired U content, say 40 to 70 per cent, with carbon averaging below 2.0 per cent, silicon below 0.75 per cent, vanadium below 0.5 per cent, and with aluminium, sulphur, phosphorus and manganese all so low as to be negligible.

If experiments with such a ferro show that uranium steels high in uranium are not valuable, but that a little uranium is useful, and if the amount required is so low that the carbon introduced by a high-carbon ferro is harmless, then the furnace might have an uncooled carbon hearth, and the ferros would contain 4 to 5 per cent carbon.

If uranium is found useful only as a deoxidizer or scavenger of oxygen and nitrogen, aluminium would not be harmful and might be advantageous, and the slag might be found wholly or in part of Al_2O_3 .

There were also two papers by J. P. SCHROEDER, one on the availability of nitrogen in fertilizers (a new method based on the nitrogen rendered water-soluble by incubation with a fertile soil), and the other paper on the fertilizer value of city wastes, and on garbage tankage, its composition, the availability of its nitrogen, and its use as fertilizer.

The author had prepared complete analyses of twenty samples of garbage tankage representing all the larger garbage reduction works in operation in this country. After removal of the oil, which is usually about 12 per

cent, there is a remainder of an average of 3.3 per cent ammonia, 7.84 per cent bone phosphate, and 0.8 per cent potash. The profitable use of this by all cities of 50,000 and more inhabitants was discussed by the author with the methods available for this purpose.

Division of Physical and Inorganic Chemistry

H. P. TALBOT was chairman of this division. Twenty-two papers were either read in abstract or read by title. The list of the papers is as follows:

F. P. SIEBEL. Negative and Positive Specific Heat of Saturated Vapor.

E. W. WASHBURN and KARL A. CLARK. The Dependence of Ion Conductance Upon the Viscosity of the Medium. (Lantern.)

J. H. WALTON and ALBERT BRANN. The Effect of Colloids on the Velocity of Crystallization of Water. (Lantern.)

B. S. HOPKINS and EDWARD WICHERS. The Separation of Erbium from Yttrium.

CLARENCE W. BALKE and EDWARD WICHERS. A Study of the Ratio $\text{Er}_2\text{O}_3 : 2\text{ErCl}_3$.

L. I. SHAW and B. H. BALL. Thermal Studies of Some Members of the System PbO-SiO_2 .

L. I. SHAW. Preliminary Studies on the Change of Conductivity with Time in the System: Methyl Alcohol-Iodine-Water.

JAMES BROWN. Use of "Cupferon" (Ammonium Nitrophenylhydroxylamine) in the Analysis of Zirconium Minerals.

S. C. LIND, C. F. WITTEMORE and J. E. UNDERWOOD. The Solubility of Pure Radium Sulfate.

S. C. LIND. Studies in Pseudo-Isotropy. I.

HARRY N. HOLMES. Silicic Acid Gels.

HARRY N. HOLMES. Rhythmic Banding.

HARRY N. HOLMES. Peptization and Gel Formation of Ferric Arsenate and Phosphate.

O. L. BARNEBY and BISHOP. Differential Iodimetry.

IV. Determination of Manganese Dioxide in the Presence of Ferric Iron.

O. L. BARNEBY. Reactions in Non-aqueous Solvents. III. Some New Double Univalent Halides.

F. H. MACDOUGALL. Density of the Transition Layer Between Liquid and Vapor. (By title.)

F. H. MACDOUGALL. Dieterici Equation of State. (By title.)

JEAN PICCARD. Colors of Second Order.

MARKS NEIDLE. Precipitation, Stability and Constitution of Hydrus Ferric Oxide Sols. (By title.)



ZINC CO., NEAR KANSAS CITY, KANSAS

MARKS NEIDLE and JACOB BARAB. Oxidation-Reduction Reactions Without the Addition of Acid. IV. Ferrous Chloride-Potassium Dichromate and Ferrous Chloride-Hydrogen Peroxide. (By title.)

MARKS NEIDLE and JACOB BARAB. Studies in Dialysis. III. Mixtures of the Chlorides of Ferric Iron, Aluminium and Chromium. (By title.)

WILLIAM D. HARKINS. Emulsification as Related to the Orientation of Molecules in the Surfaces of Liquids.

Unfortunately Mr. Siebel was not present and his paper was not read.

The paper by E. W. WASHBURN and KARL A. CLARK was of interest in so far that it gave a method for calculating h , the power to which the relative viscosity n has to be raised in the equation.

$$d = \frac{L}{L_0} \times n$$

where L signifies the conductance of one equivalent of salt, L_0 the equivalent conductance in the particular solution, d the degree of ionization and n and h the already designated quantities; h is measured by taking the conductivity measurements of the materials in question in an aqueous solution at various concentrations. Curves are then plotted from the equation:

$$\log L_0 = L_{ow} + h \log f$$

where L_0 is the desired conductance, L_{ow} the conductance of water and f the fluidity of the solution. Many curves were shown during the course of the paper.

J. H. Walton and Albert Brann were absent, their paper being read by title only.

The paper by B. S. HOPKINS and EDWARD WICHES on the separation of erbium and yttrium is essentially based on the separation of these elements by fractional precipitation of the cobalticyanide compounds.

CLARENCE B. BALKE and EDWARD WICHES then presented their paper on a study of the ratio $\text{Er}_2\text{O}_3 : 2\text{ErCl}_3$. This paper is the outcome of some investigations in connection with the determination of the atomic weight of erbium. The authors found this ratio to vary between 168.54 and 168.84. These values are slightly higher than the value accepted for the atomic weight of erbium, which is 167.7. The reason for this difference in atomic weights has not been explained.

L. I. SHAW and B. H. BALL in their preliminary paper on thermal studies of some members of the system $\text{PbO} \cdot \text{SiO}_2$ found that the curve indicated three and possibly four maxima. The first has the formula $\text{PbO} \cdot \text{SiO}_2$, the second $2\text{PbO} \cdot \text{SiO}_2$, the third $2\text{PbO} \cdot 5\text{SiO}_2$,

and the fourth $\text{PbO} \cdot 4\text{SiO}_2$. They also found that the transition point for SiO_2 was at 540 to 580 deg. C. Two eutectics with a possible third were also indicated by the curve.

Two very interesting papers were presented by C. S. LIND, C. F. WITTEMORE and J. E. UNDERWOOD. The first of the two papers was written by the gentlemen mentioned, while the second was Dr. Lind's own work. Abstracts of the papers are as follows:

The paper of the three joint authors discussed the solubility of pure radium sulphate. The solubility of RaSO_4 in water and other solutions is of practical interest since all processes for the recovery of radium from its ores involve, at some stage, the precipitation of radium together with barium as sulphate. On the theoretical side, the fact that the partial precipitation from solution of a mixture of radium and barium as sulphate, leads to no change in their relative concentrations, reminds one of the action of isotopic elements, and suggests identity of solubility of the two sulphates. The solubility of BaSO_4 at 25° has been shown by Hulett to be 2.39×10^{-6} gram per c.c. However, a comparison of the solubilities of CaSO_4 , SrSO_4 , and BaSO_4 , would lead one to expect RaSO_4 to have a solubility of the order of 1×10^{-6} gram per c.c. On the other hand, in practice it is possible in precipitating RaSO_4 from a mixture in which the $\text{Ra}:\text{Ba}(\text{SO}_4)$ ratio is 1 to 1,000,000 to reduce the concentration of RaSO_4 to the order of 10^{-11} gram per c.c.

A direct determination of the solubility has been made by the authors using 100 per cent material resulting from the co-operative work of the U. S. Bureau of Mines and the National Radium Institute. The emanation method was employed. The equilibrium was reached from both sides by dissolving RaSO_4 in H_2O and in 0.01N, 0.1N and 1N, H_2SO_4 solutions respectively, and by precipitating radium in H_2SO_4 solutions of the same concentrations. The solubilities in water and in H_2SO_4 up to 1N concentration are nearly identical, about 2×10^{-11} gram of RaSO_4 per c.c. This result shows that the solubility of RaSO_4 predicted by comparison with those of the other members of the periodic group is the true one, more than 100 times less than that of RaSO_4 . Excess of H_2SO_4 seems to have no repressive effect on the solubility concentration from zero to 1 normal. The "effective" solubility of RaSO_4 of the order of 10^{-11} gram RaSO_4 per c.c. is to be explained by the inseparability of Ra and Ba by precipitation, the BaSO_4 in solution being reduced by excess of re-

agent to its own solubility value, and radium remains in solution in the same proportion to barium as in the original solution before precipitation.

"Studies in Pseudo-Isotropy" was the title of Dr. Lind's paper. Experiments of the author and others have shown that when radium and barium are partially precipitated from a solution containing a mixture of the two, no change in relative concentration takes place. This is true for sulphate, oxalate, carbonate, and perhaps all other difficultly soluble salts, and bears an exact analogy to the inseparability of the isotopic elements. The fact that radium and barium are only pseudo-isotopic, however, is shown from the great divergence of their atomic numbers, and their ready separation by recrystallization of the chlorides or bromides. It has been shown in the preceding paper that the assumption of identical solubility of RaSO_4 and BaSO_4 , in analogy to their pseudo-isotopic action in precipitation reactions is far from the truth. Conversely, this must raise the question from the purely experimental side as to the truth of the assumption generally made of identical solubility of true isotopes.

The high degree of *inseparability* of radium and barium by reactions of precipitation (and of solution, one may add) together with their *ease of separation* by crystallization, constitute the phenomenon which the author desires to term, at least, provisionally, *pseudo-isotopy*. The combination of these two opposite effects is a most fortunate circumstance in the recovery of radium in a state of purity. Without the isotopic effect there would be no possibility of recovering radium. If it were a true isotopism there would be no possibility of separating radium from barium. The purpose of the succeeding parts of this study will be to investigate the extent, degree of exactness, state of equilibrium, and other problems relating to the pseudo-isotopy of radium and barium, as well as to extend the study to other elements. The applicability of the present theory of adsorption to the phenomenon appears especially open to investigation.

Abstracts of the other papers while of interest must be omitted, due to the fact that most of the authors were absent, and also because the subject matter is not directly of importance to the readers of this journal.

The Smoker and Banquet

The smoker was held on the evening of April 11 at the Hotel Muehlebach. The gathering was entertained by some local as well as outside talent. Music, short acts, recitations and a wireless station did much to make the evening hilarious. Especially appreciated were the curt messages over the wireless, which did much to amuse the crowd at the expense of some of the members present. As a finale to this enjoyable evening, a luncheon was served which undoubtedly added to the zest of the company.

Thursday evening a subscription banquet was in session. The toastmaster of the evening was Dr. CHAS. H. HERTY. Due to the present crisis, as would be expected, most of the speakers made addresses on patriotic subjects. So did Dr. J. STIEGLITZ, the president of the society. Dr. W. L. BURDICK's topic was patriotism, true patriotism, not mere words. Dr. E. W. WASHBURN talked on what the English chemist did for England on short notice, and mentioned that the same should be done here. Mr. J. H. ATWOOD, a banker of Kansas City, then spoke at length on what should be done at the present time. He emphasized the fact that real faith in what one is doing will of necessity result in success. Mr. ELWOOD HENDRICK's speech on publicity in chemical matters was concise and to the point. The general need of chemistry should be realized by the

public at large. In bringing chemical matters before the public Mr. Hendrick suggests that chemical terms be modified and simplified so that the ordinary man will be able to understand something of chemistry.

Undoubtedly every one present was impressed with the short and modest speech made by Col. KEALY. For there was a man who, having sacrificed his lucrative business position, had given his personal services to the country. No one felt like asking him after his speech what he had done personally to aid the country. The colonel evidently does not believe very strongly in the much quoted maxim of "letting George do it." The man of action is always admired at a time when action is so sorely needed.

The ladies present were very cordially entertained. On Wednesday afternoon a tea was given at the Muehlebach which was followed by a theater party in the evening. Thursday was spent in taking an automobile drive.

Visits and Excursions

So many interesting trips were offered that it was impossible to take them all. Thursday afternoon the guests had the pleasure of becoming familiar with the beauties of Kansas City itself. An automobile trip through the most interesting sections was taken by all at 4.30 in the afternoon. On Friday afternoon trips to the National Zinc Company, to the soap and glycerine manufacturing plant of Peet Brothers, to the Southwest Milling Company, to the Armour Packing Plant and to the Standard Oil Refinery at Sugar Creek were made, and on Saturday to the University of Kansas, the Monarch Vinegar Works, the Kansas City Galvanizing Company and Heim's Brewery.

THE NATIONAL ZINC COMPANY

This company's plant is situated about 8 miles outside of Kansas City, Mo., on the Kansas side, and covers an area of about 40 acres. It is a roaster and not a smelter, handling about 150 tons of Butte, Mont., zinc flotation concentrate per day. The concentrates are first dried and then roasted in two Hegeler furnaces and ten modified De Spirlet furnaces, the Hegeler furnaces handling 50 tons each and the ten kilns 50 more. The plant also produces 150 tons sulphuric acid per 66 deg. B $\acute{e}$, which finds a ready market in the oil refineries. Furthermore, muriatic and nitric acid are produced besides salt cake, Glauber salt, nearly chemically pure zinc sulphate and copperas. A flow-sheet of the plant is given in Fig. 2.

THE UNIVERSITY OF KANSAS

Forty miles from Kansas City lies the town of Lawrence, Kan. A hill in this flourishing town overlooking a vast expanse of the fertile Kansas plains is occupied by the Kansas State University. The many buildings of the institution are constructed of rock quarried from the locality. They present a stately and beautiful appearance. The university accommodates 3000 students, 1200 of which are young women.

Not the least of the university's attractions is the Dyche Museum, founded by the man after whom the collection is named. It occupies a building of its own. The founder endeavored to collect specimens of all American animal life and to arrange them according to their natural surroundings. It is an inspiring sight on entering the portals of the building to behold the wonderful animal groups. They would seem to be alive.

The Chemistry Building also harbors metallurgy. A series of photographs show the building and some of the laboratories and lecture rooms. Incessant work is being conducted by the able staff both along chemical

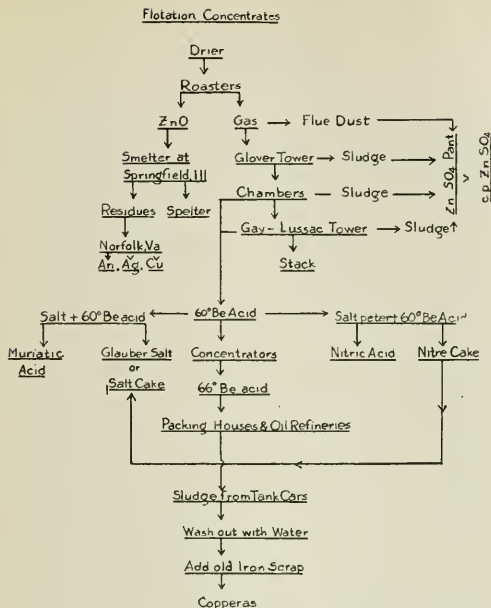


FIG. 2—FLOW SHEET OF NATIONAL ZINC CO.

and metallurgical lines, the department being very well equipped to undertake such work in all fields. An interesting feature is the apparatus for the production of liquid air and rare gases. The department furnishes liquid air and rare gases to any institution or industrial plant which wishes to carry on research work along that line. The very valuable work on the flotation process carried out here under the direction of Prof. W. A. Whitaker is well known to our readers from two articles by Professor Whitaker and his co-workers in our Vol. XIV, page 33, and Vol. XV, page 131.

Upon arriving at Lawrence the many strangers in the Chemical Society party were surprised at the largeness of the town. The city of Lawrence has a population of approximately 14,000 people, who seem to be doing things. The Bowersock Paper Mills and the Zephir Flour Mill were first inspected by the visitors. At the paper mill they produce corrugated paper box wood. The box material is put up in such shape that the buyer has nothing further to do but fold it. The hugeness of the machinery required at this plant is impressive.

Part of the morning was spent at the Haskell Indian School, where the student battalion paraded in honor of the American Chemical Society. Dinner was served at the University Club. The afternoon was spent in inspecting the buildings of the university, by riding around town, while at the local Country Club tea was served.

None of those present will forget the hospitality, not only of the people of Lawrence but especially of the faculty of the University of Kansas.

EXHIBITS

As mentioned in the earlier part of this report, it is to be regretted that so few local exhibits were on hand, those shown were mostly from outside of the Kansas City zone, but were decidedly interesting. The Brown Instrument Company of Philadelphia showed some of their temperature-reading devices. Schaar & Co. of Chicago exhibited some of their imported Japanese laboratory

ware and instruments. A. Daigger & Co., also of Chicago, demonstrated Hoyt's penetrometer, a new instrument used in testing asphalts. H. Reeve Angel & Co. of New York City showed the Whatman filter papers, and finally the Herold China & Pottery Company of Golden, Col., had a display of some of their glazed and unglazed laboratory wares.

On Saturday, April 14, this patriotic meeting came to a close. To the Kansas members who so faithfully endeavored to make this meeting agreeable to their guests the society owes sincere gratitude, and all who attended the meeting went home with a feeling of earnest respect for the brilliant possibilities of the great Middle West.

The following is a complete alphabetical list of those who registered at the Kansas City meeting:

Dr. Samuel Adler, Kansas City, Kans.; C. T. Allcutt, Kansas City, Mo.; Mr. and Mrs. H. Allen, Lawrence, Kans.; C. A. Altman, Kansas City, Kans.; H. M. Andrews, Kansas City, Mo.; Fred'k C. Atkinson, Indianapolis, Ind.; Warren H. Atwood, Ayer, Mass.; J. H. Attwood, Kansas City, Mo.; N. Bacon, Teaneck, R. I.; Wm. B. Baker, Philadelphia, Pa.; J. Bailey, Chicago, Ill.; Dr. and Mrs. J. T. Baker, Phillipsburg, N. Y.; O. L. Bameby, Madison, Wis.; R. C. Bardwell, St. Louis, Mo.; Mr. and Mrs. Wm. M. Barr, Omaha, Neb.; Geo. C. Bartek, Jr., Collinsville, Ill.; Edward E. Barton, New York; George F. Baxter, Chicago, Ill.; John S. Baxter, City Hall, K. C., Mo.; A. T. Beckley, Lawrence, Kans.; H. V. Berg, Newport, Ill.; Emily Berger, Halstead, Kans.; O. W. Berndt, Chicago, Ill.; W. D. Bigelow, Washington, D. C.; O. C. Blacklock, R. R. Bohmer, Kansas City, Mo.; Geo. Borrowman, Lincoln, Neb.; A. C. Boylston, St. Louis, Mo.; A. J. Boynton, Lawrence, Kans.; Wm. Brady, Chicago, Ill.; J. P. Brandel, Berwyn, Ill.; Roy Brant, Chicago, Ill.; Frank Brink, Chicago, Ill.; J. Brown, Indianapolis, Ind.; H. W. Brubaker, Manhattan, Kans.; F. W. Bruckmiller, Lawrence, Kans.; T. J. Bryan, Chicago, Ill.; Ralph Buffington, Lawrence, Kans.; Edmund Burke, Bozeman, Mont.; Wm. Burdette, Chicago, Ill.; Wm. C. Butcher, Chicago, Ill.; Kans.; H. V. Cadwell, Chicago, Ill.; H. P. Cady, Lawrence, Kans.; J. H. Calbeck, Blackwell, Okla.; S. Calvert, Columbia, Mo.; Fred. W. Campbell, Kansas City, Mo.; W. L. Carlyle, Stillwater, Okla.; C. E. Carls, Kansas City, Mo.; Wm. Carson, Chicago, Ill.; Kans.; H. P. Carter, Kansas City, Mo.; Edward H. Carus, La Salle, Ill.; Henry J. Cary-Curr, Chicago, Ill.; P. R. Chamberlain, Dewey, Okla.; W. McClung Chiles, Kansas City, Kans.; E. H. Child, Kansas City, Mo.; Frank Cochran, Chicago, Ill.; J. H. Clark, Albuquerque, N. M.; Lea E. Clark, Winchester, Kans.; Rowland J. Clark, Lawrence, Kans.; P. W. Classen, Lawrence, Kans.; G. H. Clay, Kansas City, Mo.; A. M. Clover, Detroit, Mich.; M. M. Colburn, Chicago, Ill.; J. E. Cook, Chicago, Ill.; Michigan, Kans.; W. F. Coover, Ames, Iowa; Marshall Crum, Brunswick, Maine; E. J. Crane, Columbia, Ohio; Walter D. Crebs, Dayton, Ohio; Roy Cross, Kansas City, Mo.; Walter Cross, Kansas City, Mo.; S. J. Cunningham, Chicago, Ill.; J. C. Curran, Kansas City, Mo.; F. B. Dains, Lawrence, Kans.; Benton Dales, Lincoln, Neb.; N. M. Dalton, Kansas City, Mo.; J. H. Davidson, Pittsburg, Kans.; Arthur L. Davis, Liberty, Mo.; G. W. Davis, Kansas City, Mo.; Frank DeLoe, Chicago, Ill.; J. DeLoe, Chicago, Ill.; James, Iowa; Frank Dravo, Kansas City; Frank H. Driggs, Baldwin, Kans.; Gaston Du Bois, St. Louis, Mo.; F. L. Dunlap, Chicago, Ill.; C. B. Dunley, Winfield, Kans.; Harold M. Eastman, Des Moines, Ia.; Col. E. E. Eckert, Chicago, Ill.; J. Edgar, Chicago, Ill.; Boulder, Colo.; Frank R. Eldred, Indianapolis, Ind.; Frank V. Emmons, Minneapolis, Minn.; W. D. Engle, Denver, Colo.; Clarence Estes, Bartlesville, Okla.; A. W. Estabrook, Kansas City, Mo.; Wm. Lloyd Evans, Columbus, Miss.; J. E. Fairbank, Chicago, Ill.; J. E. Faragher, Lawrence, Kans.; Frank Farley, Lawrence, Kans.; Frederic Fenger, Chicago, Ill.; Royal Fillmore, Kansas City; Siegfried Fischer, Jr., Golden, Colo.; Anthony P. Fonda, Independence, Mo.; Chester Fowler, Chicago, Ill.; Edw. E. Foster, Chicago, Ill.; Chas. Francis, Chicago, Ill.; Francis, Stillwater, Okla.; Geo. B. Frankforter, Minneapolis, Minn.; Francis C. Frary, Niagara Falls, N. Y.; D. K. French, Chicago, Ill.; Thos. E. Freos, New York City, N. Y.; S. Freshie, Lincoln, Neb.; J. E. Fulton, Chicago, Ill.; Kansas City, Mo.; J. Gibbs, Washington, D. C.; S. W. Gibson, Wakeney, Kans.; G. C. Glynn, Kansas City, Kans.; John P. Goheen, Philadelphia, Pa.; Howard T. Graber, Detroit, Mich.; Chas. W. Graham, Chicago, Ill.; Wm. Green, Columbia, Mo.; H. W. Greider, Topeka, Kans.; H. S. Grindley, Urbana, Ill.; A. A. Groening, Lawrence, Kans.; O. S. grouer, Ottawa, Kans.; C. F. Gustafson, Kansas City; F. L. Gutsche, Manhattan, Kans.; J. H. Gutierrez, Chicago, Ill.; C. L. Hale, Columbia, Mo.; Chas. T. Haines, Sapulpa, Okla.; H. L. Hale, Neodesha, Kans.; Mr. and Mrs. Harrison Hale, Springfield, Mo.; L. B. Hall, Rochester, N. Y.; Rolla N. Harger, Lawrence, Kans.; W. B. Hall, Kansas City, Mo.; Wm. H. Harter, Lawrence, Kans.; W. D. Hartley, Coldwater, Mich.; Winthrop P. Haynes, Lawrence, Kans.; W. P. Heath, Atlanta, Ga.; C. L. Henderson, Kansas City; Ellwood Hendrick, New York; J. H. Heppner, Springfield, Mo.; Chas. M. Hewitt, Chicago, Ill.; Nora M. Higgins, Chicago, Ill.; Chas. Hermann, Kansas City, Mo.; Chas. H. Herty, New York City; D. M. Hetler, Lawrence, Kans.; Harry H. Hill, Pittsburg, Pa.; W. H. Hillebrand, Washington, D. C.; Rudolph Hirsch, Kansas City, Mo.; H. H. Hixson, Kansas City, Mo.; Wm. Hixon, Iowa City, Ia.; Rob't. Hochstetter, Cincinnati, Ohio; Albert G. Hogan, Manhattan, Kans.; Jas. H. Holden, Lawrence, Kans.; W. W. Holland, Alton, Ill.; Harry C. Holmes, Berlin, Mo.; Major J. H. Howell, Chicago, Ill.; E. Howes, Chicago, Ill.; C. S. Hudson, Howe, Kansas City, Mo.; H. E. Howe, Montreal, C. S.; L. C. Huison, Washington, D. C.; E. Don Hughes, Lawrence, Kans.; J. S. Hughes, Manhattan, Kans.; L. C. Hugues, Hutchinson, Kans.; J. H. Hunt, Kansas City, Mo.; Wm. C. Hunter, Lawrence, Kans.; W. H. Hunter, Minneapolis; Wm. K. Ihardt, St. Louis, Mo.; John C. Ingram, Rolla, Mo.; Earl P. Insey, Roy Irwin, Lawrence, Kans.; W. M. Janney, Lawrence, Kans.; J. C. Johnson, Eureka, Kas.; Ernest F. Jones, LaSalle, Ill.; John O. Jones, Chicago, Ill.; Ernest F. Jones, LaSalle, Ill.; Lander W. Jones, Cincinnati,

Benzene, Toluene and Xylene from Petroleum*

By Gustav Egloff

In this world struggle upon which our country has launched itself two substances stand out in bold relief as fundamental in the successful prosecution of this war. These two substances are benzene and toluene. Benzene forms picric acid; and toluene forms trinitrotoluene, two of our most powerful explosives.

Our need for these two fundamental substances will soon become acute in this struggle and it is quite certain that the present number of by-product recovery plants, carburetted water gas plants, Pintsch gas machines or plants for the thermal decomposition of coal for illuminating gas, which in the main give us our present supply of benzene, toluene and xylene, will be inadequate to supply the tremendously increased need of these substances. The carburetted water gas and Pintsch gas processes produce aromatic hydrocarbons as benzene, toluene and xylene by the thermal decomposition of petroleum distillates, but they are not operated as a rule for the light oil which contains the aromatic hydrocarbons, benzene, toluene and xylene, but for the gas which requires a certain illuminating value instead of a heat value, in all but about fourteen states.

It is hoped that a knowledge of aromatic hydrocarbon formation from petroleum will help in plant practice; so as to produce maximum yields of benzene, toluene and xylene which will be sorely needed in the coming struggle.

For ninety years men have researched fitfully upon aromatic hydrocarbon production from fish, vegetable and petroleum oils. In that epoch-making paper of 1825 Michael Faraday, when analyzing the cracked oil resulting from the thermal and pressure decomposition of a fish and vegetable oil for gas making, described the discovery of a new compound which he called bicarburet of hydrogen or what is known as benzene.

Up to 1870 very little work was done until Letny isolated from the cracking of Baku residue benzene, toluene, xylene, cumene and naphthalene. In 1886 Armstrong, bending his energies toward analysis of a Pintsch gas light oil, gave the following products: benzene, toluene, xylene, trimethyl benzene and naphthalene.

A tremendous impetus was given to the cracking of petroleum oils for aromatic production in Russia due to stern economic necessity. In Russia economic coal is scarce and oil abundant. To convert part of their oil into aromatics for dye production was the goal set by the Nobel Brothers. The Russian chemists, led by Nikiforoff, solved the problem and no doubt his process for the production of aromatics for explosives is in operation at the present time.

But the first systematic work upon aromatic compounds from petroleum in the modern era was carried out by Dr. W. F. Rittman. His paper may be found in the 1915 *Journal of Industrial and Engineering Chemistry*.

From the history of the production of aromatic hydrocarbons by cracking petroleum, the following conclusions may be drawn:

1. Low temperatures produce more toluene and xylene than benzene and no naphthalene.
2. Moderately high temperatures yield more benzene than toluene and xylene, with appreciable yields of naphthalene and anthracene.
3. High temperatures result in large percentages of

*Address made at the American Chemical Society Spring meeting at Kansas City, Mo., April 10, 1917, in the Symposium on Natural Gas and Petroleum (Public Session).

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Claude Simpkins, Missoula, Mont.; F. P. Skillman, Kansas City, Mo.; Ernest R. Smith, Kansas City, Mo.; Alexander Smith, Columbia, New York City; Mr. and Mrs. Clifford Smith, Kansas City, Mo.; C. H. Sonntag, Cape Girardeau, Mo.; C. H. Spaulding, Kansas City; Jack Spencer, Junction City, Kans.; Mr. and Mrs. C. C. Spillman, Kansas City, Kans.; Elizabeth C. Sprague, Lawrence, Kans.; Louise Stanley, Columbia, Mo.; E. L. Starnes, Lawrence, Kans.; Julius Stieglitz, Chicago, Ill.; O. O. Stoland, Lawrence, Kans.; Geo. W. Stratton, Lawrence, Kans.; Mr. and Mrs. Frank Strong, Lawrence, Kans.; Mrs. Geo. S. Stroud; Robert E. Swain, Berkeley, Cal.; J. N. Swan, University, Miss.; C. C. Swanson, Manhattan, Kans.; Avis Talcott, Lawrence, Kans.; Mr. and Mrs. Frank O. Taylor, Detroit, Mich.; A. D. Thorburn, Indianapolis, Ind.; W. E. Threen, Columbia, Mo.; R. W. Titus, Emporia, Kans.; E. Todd, Lawrence, Kans.; P. E. Throwbridge, Columbia, Mo.; Fred W. Upson, Lincoln, Nebr.; C. A. A. Utt, Manhattan, Kans.; James G. Vail, Chester, Pa.; H. L. Van Velzer, Ft. Scott, Kans.; Lulu A. Vickery, Kansas City, Mo.; J. J. Vollertsen, Chicago, Ill.; Jack Waggoner, Lawrence, Kans.; Harold Wakefield, Winfield, Kans.; W. J. Walte, Kansas City, Mo.; Albert H. Walt, Kansas City; Porter M. Waldron, Columbia, Mo.; F. C. Walters, Jr.; H. E. Walton, Kansas City, Mo.; Miss Nell Ward, Lexington, Mo.; Jas. T. Ware, Independence, Mo.; E. W. Washburn, Urbana, Ill.; L. N. Waters, Columbia, Mo.; R. W. Waters, Chicago, Ill.; O. M. Weigle, Fulton, Mo.; J. E. Welin, Lindborg, Ark.; Frank E. Wellman, Kansas City; Arthur E. Wells, Salt Lake City, Utah; J. B. Wesley, Little Rock, Ark.; W. A. Whitaker, Lawrence, Kans.; H. A. Wiley, Kansas City; Edward Wickers, Urbana, Ill.; F. A. Wildger, Kansas City, Mo.; Jas. E. Wildish, E. A. Wildman, Indianapolis, Ind.; R. C. Wiley, Manhattan, Kans.; Lester T. Wilson, Chicago, Ill.; James R. Withrow, Columbus, Ohio; James A. Yates, Pittsburg, Kans.; Don O. Yeoman, Hutchinson, Kans.; C. C. Young, Lawrence, Kans.; Young, Kansas City, Mo.; A. Raymond Young, Lawrence, Kans.; Miss Zelma Zentnre, Ames, Iowa; Harper F. Zoller, Manhattan, Kans.

Co-operative Metallurgical Research.—The Massachusetts Institute of Technology has made an agreement with the United States Smelting, Refining & Mining Company, whereby the latter is to avail itself of the laboratory facilities offered by the institute instead of establishing a research laboratory of its own. The Institute of Technology has appointed Henry M. Schleicher, a graduate of 1910, to be research associate in charge of the work, the general direction resting on Prof. H. O. Hoffman, professor of metallurgy, in charge of the department of mining and metallurgy.

naphthalene and anthracene, and relatively smaller percentages of benzene, toluene and xylene.

In the past few years intensive work has been carried on to derive some knowledge as to the direction of aromatic hydrocarbon formation from that tremendous storehouse of hydrocarbons—*petroleum*.

In that period of time mixtures of ethane, propane and butane—natural gas condensate; pentanes and hexanes—petroleum ether; gasoline boiling to 150 deg. C.; kerosene boiling from 150 to 250 deg. C.; gas oil, boiling range, 200 to 350 deg. C.; paraffin wax with a melting point of 47 deg. C.; lubricating oils of various kinds; naphthene base oils and petroleum crudes, have all been subjected to temperature and pressure conditions of cracking. They all have formed aromatic hydrocarbons under right conditions. In short we can state with emphasis that all paraffin base oils or their distillates form aromatic hydrocarbons upon thermal treatment. Up to the present only one paraffin has resisted aromatic formation; this paraffin hydrocarbon being the first member of the series, methane. But there is no doubt that at a sufficiently high temperature methane will decompose to form benzene and toluene. Bone and Coward have formed acetylene upon thermal decomposition of methane and we know from the work of Berthelot, Fisher and others that acetylene polymerizes readily to benzene.

From the collective data of all the workers in the field of hydrocarbon chemistry it is quite within the facts to state that the course of aromatic hydrocarbon formation takes place somewhat as follows, from the thermal decomposition of paraffin base distillates.

High and low boiling point paraffin hydrocarbons

↓
Low boiling point paraffin and unsaturated hydrocarbons

↓
Naphthenes (alicyclic hydrocarbons)

↓
Aromatic hydrocarbons as

benzene ←-----→ toluene ↔ xylene

↓ diphenyl benzene ↓ naphthalene

↓ diphenyl benzene

↓ triphenylene

↓ hydrogen and carbon

It must be recognized that the above distillates upon cracking, do not give the same percentage of aromatics on the basis of 100 gal. of oil used. It is true they all give benzene and toluene in maximum percentage for each group, but the variation may run as high as 500 per cent difference in yield. The percentage yields depend upon the constituents present in the oil. But, on the other hand regardless of the group of paraffin oils subjected to proper thermal conditions, the products formed are aromatic hydrocarbons.

It is well known that every chemical reaction is a function of the concentration of the starting material, temperature, pressure, time of reaction and catalysts.

The factors to be covered in this address will be temperature, pressure, the time factor and the starting oil or concentration.

The Effect of Temperature on Benzene, Toluene Xylene, Naphthalene and Anthracene Formation

The starting material used was a gas oil with a boiling-point range of 92.3 per cent between 200 deg. and 350 deg. C. and the specific gravity of 0.817 at 15.5 deg. C.

The effect of temperature upon the percentage yield of benzene, toluene, xylene, naphthalene and anthracene at atmospheric pressure and in the gas phase is clearly brought out in Table 1, on basis of oil used:

TABLE 1

Temperature, Deg. C.	Per Cent Benzene	Per Cent Toluene	Per Cent Xylene	Per Cent Naphthalene	Per Cent Anthracene
150	0.8	0.6	0.6	0.0	0.0
500	0.0	0.2	0.2	0.0	0.0
550	0.0	0.6	0.3	0.0	0.0
600	0.5	1.4	0.6	0.0	0.0
650	2.5	3.1	1.4	0.0	0.0
700	3.3	2.2	1.9	0.0	0.0
750	4.7	2.0	1.6	1.3	0.0
800	4.4	1.5	1.2	2.0	0.3
875	1.1	0.1	0.06	1.5	0.2

It will be noted that the maximum yield of toluene was found at 650 deg. C. giving a percentage of 3.1 whereas the maximum of 4.4 for benzene took place at the higher temperature of 800 deg. C. The xylene formed in greatest percentage at 700 deg., giving a value of 1.9 on the basis of 100 gal. of oil used. No naphthalene formed until 750 deg. C. while a still higher temperature was required to form appreciable quantities of anthracene. All the aromatics show a maximum formation of percentage yield at a definite temperature. Of all the factors involved in the cracking of hydrocarbon oils, temperature is probably the most important. For relatively small changes in temperature, the percentage yields of benzene, toluene, xylene, naphthalene or anthracene, are greatly changed. Temperature control in cracking reactions is of primary importance.

The Effect of Pressure on the Formation of Benzene, Toluene and Xylene

Both the effect of pressure and temperature are clearly brought out in the data pertaining to a naphthene base oil. The naphthene base oil was subjected to temperatures from 550 deg. to 700 deg. C. at two pressures. The pressures used were one and eleven atmospheres. The oil used was practically a natural lubricating oil giving a boiling point range of 91.9 per cent between 150 deg. and 335 deg. C. and a specific gravity of 0.847 at 15.5 deg. C.

This naphthene base oil has given without doubt the highest percentage yield of benzene, toluene and xylene of any petroleum distillate studied up to the present time.

The data are given in Table 2.

TABLE 2

Temperature, Deg. C.	-550-		-600-		-650-		-700-	
Atmospheres	1	11	1	11	1	11	1	11
Per cent benzene....	0.9	0.4	0.9	2.6	2.6	7.2	4.2	6.5
Per cent toluene....	2.0	2.1	2.2	6.1	4.0	5.9	4.5	3.3
Per cent xylene....	2.3	3.3	2.7	5.9	3.4	5.1	2.0	2.3

An increase of pressure upon the thermolized oil had a marked effect on the percentage yields of the individual hydrocarbons benzene, toluene and xylene. In a number of cases the yield of a specific aromatic was increased over 250 per cent, by increasing the pressure from one to eleven atmospheres. As will be noted, at 600 deg. C. the percentage of toluene at atmospheric pressure gave 2.2 whereas an increase to eleven atmospheres yielded 6.1 on basis of oil used; and under the same conditions the percentage of xylene increased from 2.7 to 5.9 per cent. At 650 deg. C. the benzene increased from 2.6 to 7.2 per cent with increase from one to eleven atmospheres. In general increase of pressure increases the percentage yield of aromatic hydrocarbons and decreases the unsaturated hydrocarbon formation simultaneously.

The Time Factor in the Formation of Benzene, Toluene and Xylene

The time factor or rate of oil flow into the heated area in gallons is of great importance in all hydrocarbon reactions. The length of time in which the gaseous hydrocarbons are in the heated area can be readily governed by the rate of oil flow and by keeping the heated area of the cracking zone constant.

A gas oil was used in the following experiments: The rates of oil flow were 6, 12, 16, 23, 30 and 36 gal. per hour. An 8-in. diameter lap-welded steel tube 11.6 ft. in length was kept at temperatures of 400, 450, 500, 550, 600, 650, 700 and 750 deg. C. and at a pressure of eleven atmospheres. One of the significant points of the data in Table 3 is the fact that the formation of benzene, toluene and xylene occurs at as low a temperature as 400 and 450 deg. C. Their formation cannot be ascribed to the phenyl radical being present in the oil. The starting oil was carefully tested for aromatics and the specific gravity 0.820 at 15.5 deg. C. of the oil being too low, and with nitration and sulphonation tests no nitro derivatives or sulphonic acids were found. If the phenyl radical was present it could be present only to a minimal extent and would not account for the percentage yields of benzene, toluene and xylene formed at these low temperatures.

TABLE 3

Percentage of Benzene, Toluene, Xylene on the Basis of Oil Used for Production

Rate, Gals. Per Hour Temper- ature, Deg. C.	6	12	16	23	30	36
Per Cent Benzene by Volume						
400	0.0	..	..	..	..	..
450	1.4	0.0	0.3	0.0	..	..
500	..	1.0	0.0	0.2	0.0	0.0
550	..	3.6	1.6	0.3	0.6	0.0
600	..	4.2	4.1	0.9	0.8	1.2
650	..	4.6	6.6	3.7	1.2	..
700	..	..	..	6.2	5.4	3.5
750	..	..	..	..	5.4	5.8
Per Cent Toluene by Volume						
400	1.5	..	..	0.5	..	..
450	3.1	..	..	..	..	..
500	..	1.4	2.9	1.6	1.8	0.9
550	..	2.4	..	1.5	2.5	1.4
600	..	3.9	3.7	2.3	2.0	3.0
650	..	2.4	4.4	4.1	2.4	..
700	..	2.2	..	3.2	3.1	3.5
750	..	..	..	..	4.4	4.5
Per Cent Xylene by Volume						
400	1.6	..	..	0.8	..	..
450	3.2	1.3	2.3	1.6	1.0	1.4
500	..	2.0	..	1.4	2.2	1.1
550	..	2.6	2.1	1.3	1.8	2.4
600	..	1.1	3.4	1.3	1.7	..
650	..	0.6	1.8	2.4	2.3	3.0
700	..	..	..	1.5	2.3	2.4
750	..	..	..	..	2.5	..

Recracking of a Cracked Oil

In the industrial operation of carburetted water gas, Pintsch gas and cracking processes in general which form aromatic hydrocarbons, when the aromatics after the first cracking are separated, there is left a residue oil, disposition of which at a profitable figure is sometimes difficult. There is a conflict of opinion as to how many times an oil can be cracked profitably for the formation of gasoline, benzene, toluene and xylene. To throw light upon this point a Pennsylvania crude gas oil was subjected to temperatures of 550, 600, 650 and 700 deg. C. and pressures of one and eleven atmospheres respectively. These same conditions of temperature and pressure were applied to the same oil which had been cracked but the light oil boiling to 200 deg. C. and the 20 per cent of pitch which it contained, first being removed. The experimental results are given in Table 4.

TABLE 4

A Comparison of the Effect of Temperature at One and Eleven Atmospheres Pressure on the Per Cent of Benzene, Toluene, Xylene, Naphthalene and Anthracene on the Basis of Petroleum and Cracked Oils Used for Production

One Atmosphere Pressure									
Temperature, Deg. C.	(550)	(600)	(650)	(700)	(550)	(600)	(650)	(700)	(750)
	Pet. Oil	Cracked Oil	Pet. Oil	Cracked Oil	Pet. Oil	Cracked Oil	Pet. Oil	Cracked Oil	Cracked Oil
Per cent benzene...	0.0	0.1	0.5	2.0	0.1	0.5	2.5	1.9	2.7
Per cent toluene...	0.6	1.3	1.4	2.1	0.6	1.4	2.1	2.8	3.1
Per cent xylene...	0.3	1.6	1.0	2.4	1.4	3.0	1.9	2.4	2.1
Per cent naphthalene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4
Per cent anthracene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
Eleven Atmospheres Pressure									
Per cent benzene...	0.7	0.4	4.5	2.5	7.6	3.9	6.8	3.3	3.3
Per cent toluene...	2.7	1.4	4.6	3.4	3.2	2.8	2.2	1.3	1.3
Per cent xylene...	0.0	1.8	3.0	3.5	1.4	2.8	1.4	1.2	1.2
Per cent naphthalene	0.0	0.0	0.0	0.0	2.9	trace	2.2	4.2	..
Per cent anthracene	0.0	0.0	0.0	0.0	0.0	trace	0.2	0.8	..

There can be but one answer as to results of thermolizing a cracked oil. These can be deduced from the nature of the cracked oil itself and from data obtained in the cracking of different type oils. Depending upon the extent to which the decomposition produced by temperature and pressure has taken place, a recovered oil is obtained which contains aliphatic and aromatic hydrocarbons in proportions corresponding to these conditions. If the reaction is carried far enough, it is possible to obtain a cracked oil which is composed almost entirely of aromatic hydrocarbons. The cracked oil studied in this connection was made under conditions which gave a mixture of aliphatic and aromatic hydrocarbons. From the data of cracking dead and creosote oils resulting from the thermal decomposition of coal, it was learned that they do not decompose appreciably into low-boiling-point hydrocarbons. Hence the cracking of an oil which has already been thermolized should not give as good results for gasoline formation or for aromatics such as benzene.

Therefore one can argue that the low-boiling-point hydrocarbons resulting from the cracked oil used, came from the unchanged petroleum present in the cracked oil. Since the cracked oil only contained a percentage of unchanged petroleum the cracking will not produce as much gasoline or benzene, toluene and xylene as would the thermolization of the original petroleum oil. It would also be expected that more carbon would be formed from the cracked oil because any cracking of the aromatics present would go mainly to carbon and gas, and complex polycyclic aromatic hydrocarbons.

This brings us to the conclusion that all petroleum crudes will not crack into commercial percentages of gasoline, or aromatics due to some petroleum crudes already being thermolized partially or wholly in the earth. In other words, a cracked oil is not as favorable

From the data it can be readily noted, how important is the rate of oil flow into the heated area in forming aromatic compounds in appreciable yields. Within the gallage per hour studied here, the percentage yield of benzene decreased as the rate increased in general. The formation of toluene and xylene increased to a maximum and then decreased with increase of the gallage per hour. This indicates that to form benzene in higher percentage yields, the gaseous hydrocarbons of the starting oil must remain in the heated area a longer time or a low gallage per hour must be used. In short there is an intimate relationship between the time factor and the temperature of the hydrocarbon reaction while keeping the other conditions constant. The time factor has been overlooked in many published researches, which makes it exceedingly difficult to compare the respective data and may account for some of the discordant results one finds in the literature of cracking reactions.

an oil, for gasoline, benzene, toluene, xylene formation as an uncracked oil.

In an attempt to apply the data on the formation of aromatics gleaned from cracking in the gas phase in steel tubes, a number of tests were made upon a Lowe carburetted water gas set. The following results were obtained after a twenty-four hour run at four different temperatures at the base of the superheater. The gas oil used gave a specific gravity of 0.829/15.5 deg. C. and boiling point range of 93 per cent between 175 deg. C. and 345 deg. C.

TABLE 5

Per Cent of Benzene, Toluene, Xylene, Naphthalene and Anthracene on Basis of Oil Used for Production

Temperature, Deg. C.				
Base of superheater.....	600	675	750	800
Per cent benzene.....	1.0	1.2	1.8	2.8
Per cent toluene.....	2.1	2.6	2.7	2.7
Per cent xylene.....	2.1	3.4	3.0	2.1
Per cent naphthalene.....	0.0	0.0	1.9	2.0
Per cent anthracene.....	0.0	trace	0.1	0.9

Cracking in a standard Lowe 6-ft. set gave results somewhat lower than thermolizing in a steel tube, but this is readily explained in part on the ground of difference in the starting gas oil, and the differences in apparatus and rate of oil flow. In the four tests, maximum conditions were certainly not obtained, but the course of the reaction is exactly the same as when using a steel tube 8 in. diameter and 11.6 ft. in length.

Carrying the tests further, the gas from the 800 deg. C. run was scrubbed by passing through an absorbent oil. The amount of gas passed through the scrubber was 1000 cu. ft. The absorbing oil was then steam distilled and the light oil recovered, was analyzed for its benzene, toluene and xylene content.

In round numbers the gallonage of benzene, toluene and xylene per 1000 cu. ft. gave:

0.07 gal. benzene per 1000 cu. ft. gas scrubbed
0.06 gal. toluene per 1000 cu. ft. gas scrubbed
0.01 gal. xylene per 1000 cu. ft. gas scrubbed

Now, these figures do not appear at first glance to have much economic value, yet they are interesting when one considers that according to Lesh's report published in the Geological Survey there were made in the United States 124,129,569,000 cu. ft. of carburetted water gas in 1915.

Now, by making a national heat standard for gas, while a heat standard is used only in fourteen states or so at present, these fundamental substances could be recovered. At present with few exceptions the gas is burned with illuminating standards.

A few plants scrub the gas from carburetted water gas, but the bulk do not.

By putting in a simple scrubbing system and stills in carburetted water gas plants in this country the total gallonage of benzene, toluene and xylene which could be recovered per year on the basis of the 1915 report would be as follows:

Gallons benzene.....	\$,689,000
Gallons toluene.....	7,448,000
Gallons xylene.....	1,241,300

in round numbers.

At present prices of benzene, toluene and xylene the economic value of the above gallonage would be:

Value of benzene based upon a present price of 0.55 per gallon, \$4,779,000. Value of toluene price 1.75 per gallon, \$13,034,000. Value of xylene at 0.60 per gallon, \$744,600.

The present prices of aromatics were taken as the low quotation of the April 2, 1917, copy of the *Oil, Paint & Drug Reporter*.

In round numbers the saving in economic value at present prices of the three aromatic hydrocarbons from carburetted water gas scrubbed would be \$19,000,000.

And we must recognize the fact that these figures are based upon the 1915 census. It is quite safe to say that this amount has increased about 20 per cent since that time, this being based upon an extrapolated value from previous years.

In this report only the benzene, toluene and xylene resulting from the thermal and pressure decomposition of petroleum oils has been given. This is a prolific and almost inexhaustible supply for the fundamental substances in explosives, and will fully yield all that this present war may demand. Coal, as all know, yields tremendous quantities, but there is a part of the light oil which is also a prolific source for the production of benzene, toluene and that is xylene. And it yields readily to benzene, and toluene formation by heat, and pressure treatment, as also with catalysers at low temperatures.

CONCLUSIONS

1. All groups of paraffin hydrocarbons have formed benzene and toluene upon thermal treatment with one exception, methane.

2. We can control the yields of aromatic hydrocarbons so as to form benzene, toluene, xylene, naphthalene or anthracene in maximum quantity.

3. The group of paraffin hydrocarbons present in the petroleum distillate is of great importance in forming aromatics in large yields.

4. All paraffin hydrocarbons form aromatics but with varying percentage yields, on basis of oil used.

5. The temperature at which the petroleum oil is cracked is of primary importance in giving maximum yields of benzene, toluene, xylene, naphthalene and anthracene. The effect of pressure and the time factor is of lesser importance within limits than temperature. But, the three factors of temperature, pressure and time are intimately related and a nice balance must be held to yield maximum percentages of aromatic hydrocarbons.

6. A cracked oil is not so well adapted to aromatic or gasoline production as is a petroleum oil.

7. Whatever cracking takes place to lower boiling point hydrocarbons from a cracked oil may be attributed to a large extent to unchanged petroleum in the cracked oil and not to its aromatic constituents.

8. There is a limit to the number of times which an oil can be re-cracked, because of the tendency of the reaction to form aromatic compounds which decompose neither into gasoline nor members of the benzene series appreciably, but toward the ultimate products, hydrogen and carbon.

9. The course of aromatic hydrocarbon formation from paraffin base petroleum distillates in all likelihood is as follows:

High and low boiling point paraffin hydrocarbons

↓
Low boiling point paraffin and unsaturated hydrocarbons

↓
Naphthenes (alicyclic hydrocarbons, polymethylenes)

↓
Aromatic hydrocarbons as

benzene ←→ toluene ↔ xylene

↓
diphenyl naphthalene

↓
diphenylbenzenes

↓
triphenylene
carbon and hydrogen

The Embrittling Action of Sodium Hydroxide on Mild Steel and Its Possible Relation to Seam Failures of Boiler Plate

By Paul D. Merica

For some time past the Engineering Experiment Station of the University of Illinois has been making an investigation into the causes of the seam failures of boiler plates, which have been occurring there and elsewhere in that part of the country. The author was engaged during the early part of 1914 in this investigation, and studied at that time the possible deteriorating effect of alkali on the steel of the plates, following an idea advanced by Prof. S. W. Parr. It seemed advisable to delay the publication of the results of this investigation until further work at the station, described by a Bulletin of the Station just issued, should relate if possible more fully the action of the alkali on steel to the actual boiler failures.

The author wishes to express his appreciation of the very cordial co-operation and aid of Prof. S. W. Parr and of Prof. H. F. Moore; Dr. T. E. Layng aided most efficiently in most of the testing work.

THE CHEMICAL ACTION OF SODIUM HYDROXIDE UPON IRON AND STEEL

It is well known¹ that at ordinary temperatures iron is passive or non-reactive to hydroxide solutions having OH ion concentrations in the range of approximately 10^{-1} to 2N sodium hydroxide. However, if the concentration of the hydroxide is increased the passivity vanishes and a reaction of the sort indicated below may take place. This is shown by the electrolytic potential of iron to solutions of sodium hydroxide or potassium hydroxide. A curve, Fig. 1, is reproduced from Heyn and Bauer's work,² showing the emf. at ordinary temperatures of iron to solutions of varying hydroxide concentration. It is seen that an anodic reaction of the type



becomes possible at hydroxide concentrations of about 5-10 N. At higher temperatures the reaction between sodium hydroxide and iron is more rapid, and Krassa³

has shown that hydrogen gas is generated by the action of N sodium hydroxide on steel at 150-200 deg. C. We may expect then at higher temperatures to obtain hydrogen by the action on steel of sodium hydroxide of at least higher concentrations.

THE EFFECT OF NASCENT HYDROGEN UPON THE PHYSICAL PROPERTIES OF STEEL

The researches of Ledebur⁴ on the so-called "pickling brittleness" have shown that very marked brittleness is produced in steel by treatment with dilute acid or by making it the cathode in an electrolytic cell. In both cases "nascent" hydrogen is generated on the surface of the steel, and reacts with it in some way not yet clear to produce a material which is much less tough than the original steel. The analogy of the two cases is now apparent, and it is not surprising to find that in fact the action of sodium hydroxide on steel at higher temperatures, at which this reaction first proceeds with appreciable velocity, produces a brittleness comparable with the "pickling brittleness" and which is due to the same cause.

In Ledebur's study of this type of brittleness he found that it was not possible by the static tensile or compression test to show the deterioration which took place upon generating nascent hydrogen on steel. The various quantities measured, including elongation and reduction of area remained practically unchanged. Some slight change was detected by a transverse static test, but when an alternating stress or an impact test was used the deterioration was at once very definitely indicated by reductions of 25-75 per cent of the toughness as so measured. It was for this reason that it was decided not to rely alone upon a tensile test in this investigation, but to include also some form of impact and alternating stress test.

There is reference in the literature to the effect that sodium hydroxide has a "destructive effect" on mild steel,⁵ but the author has unfortunately been unable to obtain this article, in which description is given of the deterioration of steel exposed to hot alkaline solutions.

An article by Andrews recently appeared⁶ in which the author showed by some simple bending tests the effect of treatment of small strips of iron with hot alkali. He states that a thin strip of mild steel became very brittle and "crystalline" after immersion for one week in sodium hydroxide solution at 100 deg. C., and advances a theory to account for it, to which reference will be made later.

DESCRIPTION OF TESTS, MATERIAL, ETC.

The physical tests were carried out with small test specimens. Whatever effect the alkali has upon the steel is likely to be localized at the surface; in order that the tests may be sensitive a large ratio of surface to volume or cross-section is desired.

The Tensile Tests were carried out on a 10,000-lb. Olsen machine, using the same speed for all tests; an automatic recording device was attached and the area under the stress-strain curve determined. The specimens possessed a diameter of 0.150 in. over a test length of 1.25 in.

The Impact Tests were carried out with an apparatus assembled at the station, of which a photograph is shown in Fig. 2. The weight of the pendulum hammer was 16.5 lb.; the height of fall of its center of inertia, 24.6 in.; the round specimens, 4.5 in. long, were notched always with a right-angle tool on the lathe, and were

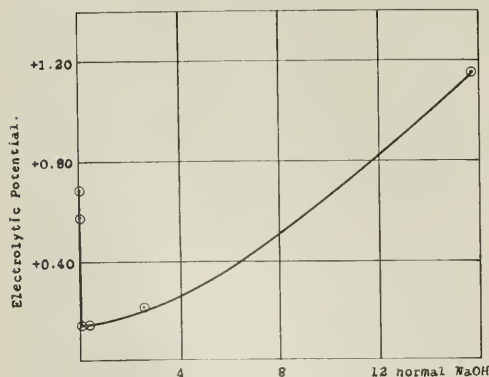


FIG. 1—THE ELECTROLYTIC POTENTIAL OF IRON TOWARD SODIUM HYDROXIDE SOLUTION (ACCORDING TO HEYN AND BAUER)

Abcissas—Concentration of NaOH in mols per liter
Ordinates—EMF of Fe/NaOH/normal calomel electrode

¹Stahl und Eisen, 1887, p. 681; 1889, p. 745.

²Stromeier, Manchester Steam Users' Association, 1910.

³Andrews, Transactions of the Faraday Society, March, 1914.



FIG. 2—IMPACT TESTING MACHINE

broken transversely. The specimens were machined to a uniform diameter on either side of the notch for a distance of 0.5 in.

During the preliminary work some rather interesting results were obtained showing the dependence of the specific impact work of rupture on the diameter of the specimen at the bottom of the notch and on that immediately adjacent to it. These results are shown graphically in the Figs. 6 and 7 (d represents the former diameter, D the latter). Values of 0.140 in. for d and 0.235 in. for D were chosen for the ensuing tests. With this machine, and under the conditions realized in the tests, values of the specific impact work could be checked to within from 10 to 15 per cent on specimens notched at the same time and under the same conditions.

The Alternate Stress Tests were made on a small bench lathe, the arrangement of which is shown in Fig. 8. The specimen was supported in a draw-chuck at one end, the load being carried by a bushing and ball-race frame at the other. The load was applied by means of a spring balance through a universal joint to the ball-race frame. The specimen had the shape shown in Fig. 4, the notch being cut with a right angle tool. The load was applied in each case with the same lever arm, and the number of alternations to rupture measured with a rotation counter, using a constant speed of about 120 revolutions per minute. The value of the load was so chosen that about 300 revolutions sufficed to rupture the specimen. Such a repeated bending test with small number of revolutions to rupture has undoubtedly been successful in indicating brittleness in many cases, in which the tensile test has failed to show any abnormal condition, as for example in the case of high phosphorus brittleness,⁷ of pickling brittleness,⁸ and in the case of overheated steel.⁹

Fig. 9 shows some results indicating the effect of varying the diameter at the base of the notch, keeping the other conditions constant; it was decided to use 0.195 in. as a value for d . Under these conditions variations in results on the same material did not usually exceed from 5 to 10 per cent, although occasionally much greater ones of 50 and even 75 per cent were noted.

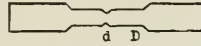


Fig. 3. Impact test specimen

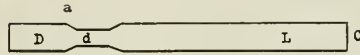


Fig. 4. Alternating stress test specimen

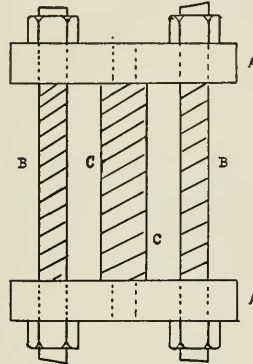


Fig. 5. Frame for subjecting specimens to action of alkali while under stress

CHEMICAL TREATMENT OF THE SPECIMENS

The action of the alkali, sodium hydroxide, was studied at three temperatures, 100 deg., 180 deg. and 280 deg. C., using in each case a constant concentration of 13.6 N alkali (except as noted in the tables). At the two higher temperatures the treatment of the

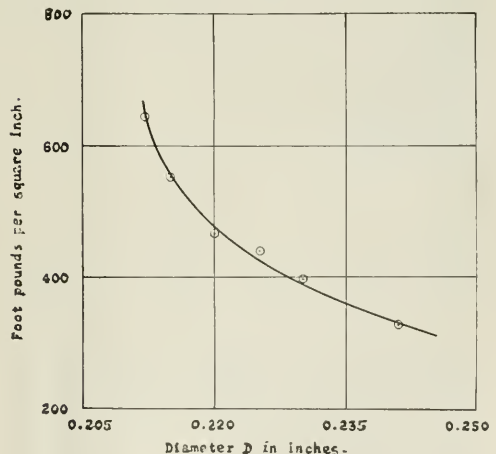


FIG. 6—THE IMPACT TEST

Effect of variations in the diameter D of the specimen (d constant) on the specific impact work.
Abscissas— D in inches
Ordinates—Specific impact work in foot pounds per square inch

⁷Kommers, Proc. Int. Soc. Testing Materials, 1912.

⁸Ledebur, loc. cit.

⁹Heyn, Handbuch der Materialkunde, 1912.

specimens could not be accomplished in a glass tube for the reason that the latter would be quite readily attacked by the alkali. It was necessary to use iron pipe for this purpose, and it was discovered that at these high temperatures it was not possible to make a pressure-tight joint with an ordinary pipe cap; such a joint will hold steam pressure at those temperatures, but when the alkali solution was used it would rapidly evaporate. It was necessary to weld the top of the pipe with the oxy-acetylene torch after the solution of alkali and the specimens had been put in.

Only one material was used in these tests, a $\frac{1}{4}$ -in. steel wire of the following composition:

C	0.18 per cent
P	0.024 per cent
S	0.045 per cent
Mn	0.42 per cent

Five hundred feet of this wire were annealed in a gas furnace for test.

THE RESULTS OF THE PHYSICAL TESTS

Table I gives the results of the first series of tests, in which all values are expressed for the sake of convenience in terms of percentages of the corresponding values for the untreated material. The results of the impact and of the repeated bending tests are the averages of five tests, those of the tensile tests of two tests.

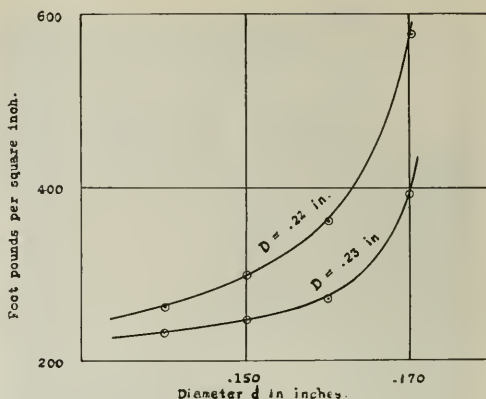


FIG. 7—THE IMPACT TEST

Effect of variations in the diameter d at bottom of notch (D constant) upon the specific impact work.

Abscissas— d in inches

Ordinates—Specific impact work in foot pounds per square inch

sodium hydroxide on the yield point or on the ultimate strength. The impression is gained from a study of the elongation that its value is lowered a few per cent

TABLE I—SERIES I OF TESTS SHOWING EFFECT OF ALKALI TREATMENT ON PHYSICAL PROPERTIES OF STEEL

Solution	Time of Treatment in Days	Temperature of Treatment, Deg. C.	TENSILE TEST			Area Under Stress-strain Curve ¹ , per Cent	Alternate Bending Test, Number of Alternations to Rupture ¹	Impact Test, Specific Impact Work ¹	Hydrogen Evolution
			Yield Point, Lbs. per Sq. In. ¹	Ultimate Tensile Strength Lbs. per Sq. In. ¹	Elongation in $1\frac{1}{4}$ In., per Cent ¹				
13.6 N NaOH	17	100	116	102	100	112	85	92	.....
13.6 N NaOH	30	100	101	102	83	110	110	108	.....
13.6 N NaOH	10	180	110	100.5	98.0	110	64	.....	Strong
13.6 N NaOH	15	180	100.8	102	97.4	107	69	.....	Strong
13.6 N NaOH	15	180	103.0	98.5	82	92.0	82	100	Strong
13.6 N NaOH	19	180	80	97	88	92.5	88	103	Slight
13.6 N NaOH	23	180	.....	.....	.....	.....	90	88	Strong
13.6 N NaOH	24	180	.....	.....	.....	.....	.....	.....	.....
13.6 N NaOH	12	280	100.6	98.6	104.0	113	79	.....	.....
13.6 N NaOH	5	280	97.6	95.6	67.0	70	56	.....	Strong
13.6 N NaOH	8	280	99.6	100.1	97.0	110	57	83	Strong
13.6 N NaOH	10	280	98.5	96.0	87.0	120	80	102	Strong
13.6 N NaOH	13	280	99.0	94.4	98.0	104	73	104	None
13.6 N NaOH	15	280	97.6	101.0	90.6	91	75	92	Slight
13.6 N NaOH	15	280	.....	.....	.....	.....	77	104	Strong
13.6 N NaOH	16	280	107	97	97	104	79	94	Slight
13.6 N NaOH	15	.....	.....	.....	.....	.....	.....	.....	.....
13.6 N NaOH + Na ₂ Cr ₂ O ₇	17	180	102	104	104	117	126	106	None
13.6 N NaOH + Na ₂ Cr ₂ O ₇	19	180	116	105	101	116	105	102	None
13.6 N NaOH + Na ₂ Cr ₂ O ₇	19	180	.....	.....	.....	.....	.....	.....	Yes
13.6 N NaOH + Na ₂ Cr ₂ O ₇	17	280	96.5	101	87	94.5	119	86	None
13.6 N NaOH + Na ₂ Cr ₂ O ₇	19	280	96.5	96	94	101	93	107	Slight
13.6 N NaOH + Na ₂ Cr ₂ O ₇	20	280	.....	.....	.....	.....	.....	.....	None
Na ₂ CO ₃	23	180	.....	.....	.....	.....	104	109	Some
Na ₂ CO ₃	.....	180	.....	.....	.....	.....	.....	.....	Some
Na ₂ CO ₃	16	280	101	100	91	97	131	104	None
Na ₂ CO ₃	24	280	.....	.....	.....	.....	.....	.....	None
Boiler scale	09	180	106	101	94	104	91	94	.....
Boiler scale	23	180	.....	.....	.....	.....	90	103	Strong
Boiler scale	19	280	.....	.....	.....	.....	.....	.....	Slight
Boiler scale	19	280	.....	.....	.....	.....	.....	.....	None

¹The results are expressed in terms of percentages of the values on original untreated material.

Column 9 gives an indication of the amount of the evolution of H₂ during the action of solution, as evidenced by the amount of pressure developed. The material in the untreated state had a yield point at about 37,700 lb., an ultimate strength of 55,900 lb., and an elongation of 31 per cent on $1\frac{1}{4}$ in. The area under the stress-strain curve was 1190 ft.-lb. per cubic inch. The specific impact work in the bending test when a deep notch ($d = 0.150$ in.) was used was 248 ft.-lb. per square inch (5.36 mkg. per sq. cm.).

The results of the tensile test show no effect of the

by treatment in sodium hydroxide, which can also be said, although to a less degree, of the area under the curve. At the same time the lowering is hardly very marked, many of the values being lowered only an amount easily within the experimental error.

When the results of the repeated bending test are considered, however, the effect of sodium hydroxide in embrittling is at once apparent, the number of alternations of stress withstood after treatment being on an average about 20 per cent lower than the values for the untreated material for the two higher temperatures.

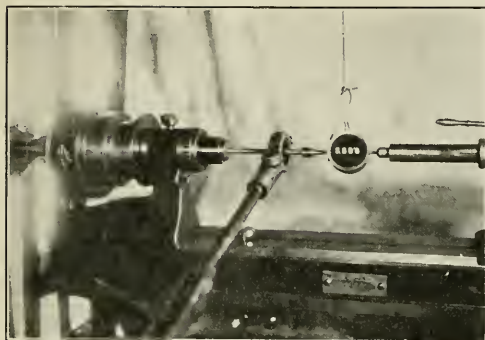


FIG. 8—ALTERNATE BENDING TESTING MACHINE

There are also only two cases in which there is no decrease.

In order to make these results more conclusive and at the same time to test the effect of time and temperature of treatment on the values obtained two more

TABLE III—SERIES 3 OF TESTS SHOWING EFFECT OF ALKALI TREATMENT ON PHYSICAL PROPERTIES OF STEEL

Solution	Time of Treatment in Days	Temperature of Treatment, Deg. C.	Alternate Bending Test. Number of Alternations to Rupture ¹	Impact Test. Specific Impact Work ¹	Hydrogen Evolution
13.6 N NaOH	9	200	90	88	Strong
13.6 N NaOH	14	200	106	89	Strong
13.6 N NaOH	15	200	106	100	Strong
13.6 N NaOH	14	200	106	100	Strong
25N NaOH	15	200	82	86	Strong
N/10 NaOH	15	200	108	100	None
13.6N NaOH	9	200	106	104	None
13N Na ₂ Cr ₂ O ₇	14	200	100	89	None
13N Na ₂ Cr ₂ O ₇	15	200	108	108	None
25N NaOH	15	200	93	93	None
25N Na ₂ Cr ₂ O ₇					None

¹The results are expressed in terms of percentages of the values on original untreated material.

series of tests were run, the results being given in Tables II and III, and corroborating those of the first series.

The rather striking fact which is noticed in all the tests is that at both temperatures, 280 deg. C. and 180 deg. C., the brittleness increased up to about a week's time and then decreased, the material recovering either partially (first series) or even wholly (second series)

TABLE II—SERIES 2 OF TESTS SHOWING THE EFFECT OF ALKALI TREATMENT IN STEEL

Solution	Time of Treatment in Days	Temperature of Treatment, Deg. C.	TENSILE TEST			Area Under Stress-Strain Curve ¹ , Per Cent	Alternate Bending Test. Number of Alternations to Rupture ¹	Impact Test. Specific Impact Work ¹	Hydrogen Evolution
			Yield Point, Lbs. per Sq. In. ¹	Ultimate Tensile Strength, Lbs. per Sq. In. ¹	Elongation in 1½ In., Per Cent ¹				
13.6N NaOH...	8	100	96	101	96	104	95	113	
13.6N NaOH....	30	100					90	87	
13.6N NaOH....	8	180	115	100	102	110	63	76	Strong
13.6N NaOH....	3	280					83	97	Strong
13.6N NaOH....	8	280	98	97	104	109	88	97	Strong
13.6N NaOH....	8	180	100	102	90	97	103	100	None
13N Na ₂ Cr ₂ O ₇ ...	8	280	94	102	88	96	96	122	Slight

¹The results are expressed in terms of percentages of the values on original untreated material.

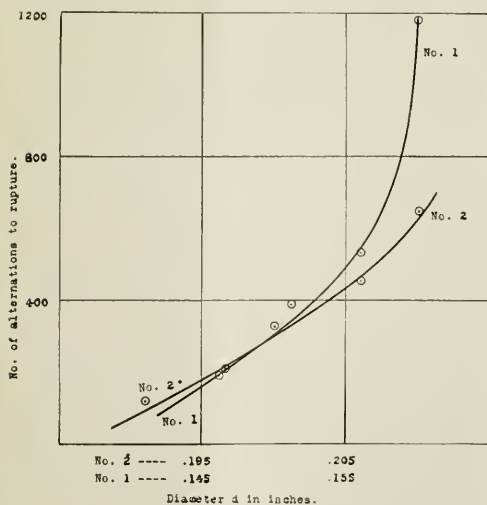


FIG. 9—THE ALTERNATE BENDING TEST

Effect of variations of d (D and M , the bending moment constant) on the number of alternations to rupture.
 Abscissas— d in inches
 Ordinates—No. of alternations to rupture

its original mechanical properties. This is indicated in the curves showing the results of the first series of repeated bending tests given in Fig. 10.

Even more striking is the complete recovery noted in the third series. This was also noticed by Andrews in his work, and there is advanced here a tentative explanation of this rather curious phenomenon. During the first period of the action of the alkali, before the oxide product of the corrosion has been formed, the hydrogen liberated by this action is actually given up in the nascent state on the iron, and absorbed by it. Later the H_2 formed by the anode solution of the iron is given up at the cathode, which is now the very electronegative oxide, and can come in contact with the iron itself only by secondary diffusion or after it has formed in the molecular state. Such hydrogen has been shown to have little or no effect on the mechanical properties of steel. Therefore, as soon as the oxide has formed in a thick and dense layer over and near the iron, the embrittling action of the chemical agent ceases. It has also been shown by Heyn (loc. cit.) and others that chemical (pickling) brittleness is relieved by heating for a short time at even such temperatures as 100 deg. C., the hydrogen evidently diffusing out of the material, leaving it as it was originally. Therefore, after the embrittling action of the alkali has ceased, that brittleness which has already been induced is removed by the heating to which the material is further subjected.

The effect of the temperature of treatment on the

results can be best seen from the Table II, from which it is evident that at the higher temperature the brittleness is developed in a shorter time than at the lower, and the effect produced by the alkali at this higher temperature seems to be greater also.

A survey of the results from the three tables shows, as would be expected, that the action of the alkali is more marked at the higher concentration of 25 N than at 13 N, and no effect at all is produced by the N/10 alkali at 200 deg. in two weeks, although there was quite noticeable corrosion.

As it has been suggested by Stromeyer in his article that steel in tension was more affected by treatment with sodium hydroxide than when without stress, and as such a fact would, under the circumstances, be of great significance, some tests were carried out to see whether such an acceleration of the embrittling action could be noticed. Two specimens were put in a frame, a sketch of which is given in Fig. 5. The specimens BB were then put in tension by screwing up the bolts, the amount of stress being approximately measured with a strain gage. Since the specimens were notched it was impossible to calculate the fiber stresses at the notch; the average stress applied to the bottom of the notch was about 15,000 lb. Three of these frames were then welded up with the solution in a 14-in. length of 4-in. pipe and heated the desired length of time. It

concentration of hydrogen is greatest at the surface and becomes less toward the center, the results of these tests probably do not give the proper evaluation of the amount of brittleness caused at the surface. Further, in turning down the specimen after the treatment about 15 per cent to 20 per cent of that material is removed which is most affected by the treatment.

CAUSE OF THE EMBRITTLING EFFECT

There seems to be little doubt but that the embrittling effect of sodium hydroxide on steel above established is due, as suggested, to the absorption by the steel of nascent hydrogen. However, there are two other possibilities which may be considered here.

First, there is the possibility that the alkali actually works into the metal, eating out the "amorphous inter-crystalline cement" which, being thermodynamically less stable than the crystals would be first attacked. This would cause a brittleness akin to that caused by burning or overheating, and fracture would be inter-crystalline. Second, Andrews claims that sodium hydroxide causes a "crystallization," by which he means a coalescence of the smaller crystals into larger ones. This effect would then also be the same as that caused by overheating.

It is not believed by the author that sodium acts in this latter way, or at least that the embrittling effect is due to any such action. It is in the first place diffi-

TABLE IV—EFFECT OF SODIUM HYDROXIDE TREATMENT ON SOFT STEEL UNDER STRESS

Solution	Time of Treatment in Days	Temperature of Treatment, Deg. C	Alternate Bending Test. Number of Alternations to Rupture ¹	Impact Test. Specific Impact Work ¹	Hydrogen Evolution
25N NaOH	8	180	76	86	
25N NaOH	8 (t)	180	95	65	
13N NaOH	14	190	97		Slight
13N NaOH	14 (t)	190	110		

¹The results are expressed in terms of percentages of the values on original untreated material.

was found very difficult to make this larger weld absolutely tight and free from pinhole leaks.

The results of these tests are given in Table IV in which the letter *t* signifies that those specimens were in tension during the treatment.

As far as can be seen from the results of the two runs made, the material in tension shows if anything less tendency to undergo the embrittling attack of the alkali than that which is not. In view of the conflicting testimony on this point (Stromeyer) it should be more thoroughly investigated.

Owing to the fact that the

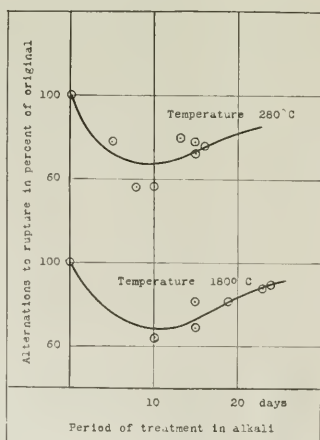


FIG. 10—EFFECT OF ALKALI TREATMENT AT HIGHER TEMPERATURES ON THE TOUGHNESS OF STEEL AS INDICATED BY THE ALTERNATING STRESS TEST

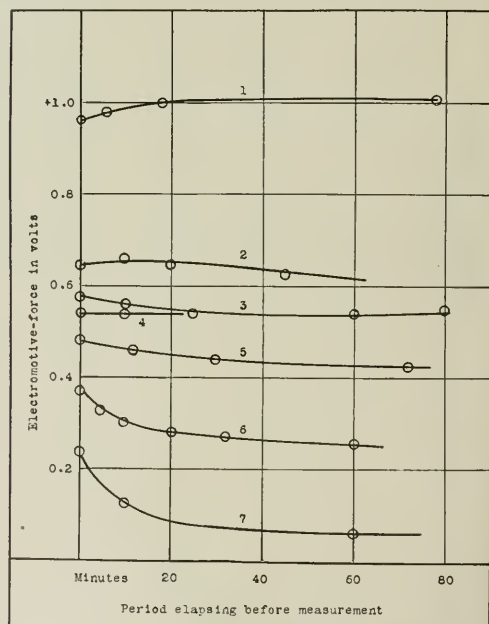


FIG. 11—ELECTROMOTIVE-FORCE OF STEEL UNDER VARIOUS CONDITIONS

Curve 1—EMF of steel to 13.6 N NaOH solution
 Curve 2—EMF of steel to 0.1 N NaOH after treatment for 10 days in 13.6 N NaOH at 180 deg. C.
 Curve 3—EMF of iron to 0.1 N NaOH after 10 minutes' immersion in dilute H_2SO_4
 Curve 4—EMF of iron to 0.1 N NaOH after one week treatment with 50 per cent NaOH at 110 deg. C.
 Curve 5—EMF of steel to solution which is 13.6 N both to NaOH and to $Na_2Cr_2O_7$
 Curve 6—EMF of iron to 0.1 N NaOH in untreated state
 Curve 7—EMF of steel to 0.1 N NaOH in untreated state
 EMF's of curves 1, 2, 5 and 7 were measured with the Hg/HgO. N/10 NaOH electrode, the others with the Hg/HgCl. N/10 KCl electrode
 Curves 3, 4 and 6 are from data by Dr. Hirschkind

cult to see in just what manner the presence of sodium hydroxide could cause a coalescence to take place in the week's time which it takes to develop this brittleness at the comparatively low temperature of 100 deg. to 200 deg., in material in which the coalescence is known to proceed at an almost infinitesimally slow rate at these temperatures.

It has been further shown that the material in contact with sodium hydroxide at higher temperatures undergoes a gradual recovery of the original mechanical properties, a phenomenon which has already been given an explanation and which cannot be reconciled with any theory making "recrystallization" responsible for this effect.

This explanation was, however, given some direct attention in the following manner. Pieces of the material used in the tests and also of electrolytic iron, about 1 in. long, were turned down to a uniform diameter and cut in two. One-half of the original specimen was then treated with the alkali, and the structures of the two compared, particularly at the edge exposed to the action of the alkali. No increase in grain size was noticed as a result of the treatment, even at the extreme edge of the specimen.

Attention has been called to the fact that hydrogen was evolved during the action of the alkali on the steel at all temperatures above 100 deg.; pressure was developed within the steel containing "bomb," the gas analyzing about 94 per cent hydrogen.

A rather striking proof of the fact that some molecular change takes place in iron during the action of alkali is found in a study of its emf. toward any strength of solution, more conveniently N/10 sodium hydroxide, before and after treatment in concentrated alkali at temperatures of 100 deg. and more. This matter was studied first by Dr. Hirschkind and later by the author, and it was found by both of us that this potential after treatment is considerably higher than that of the original material, and that it extends into the specimen from the surface for a considerable distance, which was proved by turning off from 0.015 to 0.030 in. before measuring. This increase in potential is also caused by immersion for a few minutes in dilute acids or by cathodic polarization.

The measurements, the results of which are shown in the curves in Fig. 11, were made by the ordinary compensation method. The specimens were in all cases sandpapered or turned down after alkali treatment, and paraffined for about 1 in. below and above the surface of the solution with which their potential was being measured. Curves 3, 4 and 6 are taken from Dr. Hirschkind's data; they show the potential in N/10 sodium hydroxide of steel against Hg/HgCl · N/10KCl as a function of the time. Curve No. 6 gives the potential for the untreated steel, No. 4 for the same after a treatment of one week in 50 per cent sodium hydroxide at 100 deg. C., and No. 3 the potential after about ten minutes immersion in diluted sulphuric acid. It is to be noted that cathodic polarization gives also the same effect as the latter. Curves 2 and 7 also show this effect, the measurements being in N/10 sodium hydroxide against Hg/HgO · N/10 sodium hydroxide, No. 7 shows the potential of untreated material, and No. 2 that after treatment for ten days in 13.6 N sodium hydroxide at 180 deg. The potential is seen to be in all cases higher after treatment of any sort that evolves nascent hydrogen on the steel than for the original material. This fact would seem to point unmistakably to a molecular change in the iron.

This high potential seems to disappear in many cases after some time and after heating to 100 deg.-200 deg. in air, but no relation was established between the

presence of this potential and the existence of brittleness, as the potential seemed to be increased during the treatment long before the brittleness manifested itself.

PREVENTION OF THE EMBRITTLING EFFECT

Another demonstration of the truth of the hydrogen theory was found in studying means to prevent the deteriorative effect of sodium hydroxide. Of such means the first and most natural which suggests itself is the removal of the active agent, to a discussion of which reference will be made later.

If hydrogen is the cause of this brittleness, it should be possible to remove it by adding an oxidizing agent, as, for example, sodium dichromate, to the solution, which would depolarize the iron electrode. Preliminary measurements of the potential of iron to concentrated solutions of sodium hydroxide showed that at all temperatures readily accessible to such measurements (20 deg.-110 deg.) this potential was very considerably lowered by addition of the dichromate in equivalent proportions; that is, for 1 mol of sodium hydroxide there was used 1/6 mol of the dichromate. Curves showing this are given in Fig. 11, the measurements having been made at 80 deg. C. Not only is curve No. 1, which gives the potential of iron in 13.6 N sodium hydroxide, higher (more electropositive) than No. 5, which gives the same in a solution which is about 13 N to both the alkali and the dichromate, but it also slopes upward, while No. 5 slopes the other way. Since the hydrogen potential in an alkaline solution of this concentration is calculated to be about +0.930, it should be impossible for hydrogen to be generated in the solution in which the Na₂Cr₂O₇ is present. Similarly, judging from these data the corrosion in the dichromate solutions should be at least less well marked than the sodium hydroxide solutions alone. In order to settle these points parallel physical tests were run using the solution with equivalent amounts (13 N) of both the alkali and the dichromate. The results of these tests are given also in the Tables I, II and III.

It was first of all noticed in opening the pipes after the treatment that whereas, as has already been mentioned, H₂ was present in those which contained sodium hydroxide alone, only a few of the pipes containing the dichromate had generated hydrogen during the treatment. This is shown in the table. The corrosion in all cases was much less, being almost negligible in the case of less than a week's treatment at 180 deg., and was moreover of an entirely different character. This is shown in the photograph, Fig. 12. Whereas with pure sodium hydroxide the surface was rough and covered with a porous, loose deposit of black Fe₃O₄, or a hydrated form of it, which was at the higher temperatures 180 deg.-280 deg. in the form of a beautiful black crystalline sheen, with addition of Na₂Cr₂O₇ the surface was smooth and covered with a thin, dense, tightly adherent coating of brown Fe₂O₃. In the latter case the marks of the lathe tool were generally still visible, as can be seen in the photograph.

The toughness as indicated by the repeated bending test apparently suffers no deterioration under the action of sodium hydroxide and sodium dichromate in the periods of treatment used.

SEAM FAILURES OF BOILER PLATE

A type of failure which is related to the question discussed above is the failure of boilers at the seams and tube caps.¹⁰ Fissures are found in such boilers, of the water tube type, at the seams of the steam drum

¹⁰These failures occurred in the university boilers and were noticed first in the summer of 1912.

and cross box, such cracks being on the inside of the seam, hence not easily visible and the more dangerous. An accompanying feature was the persistent leakage at these seams with formation of an alkaline incrustation. This phenomenon is as would be expected more marked at the front part of the drum and the cross box, where the temperature and stress changes are the greatest, and is to be found practically only below the water line.

Consultation with the builders of the boilers brought out the

fact that there were to be found power plants in certain localities which were experiencing practically the same difficulty. The fact was also brought out by them that faulty material as a cause for these failures was scarcely to be considered, since not only different heats of material were to be found in the university boilers, but the parts were even assembled from different mills and steam manufacturers. Tests both physical and metallographic also showed that the material satisfied the specifications. For the same reason, namely, that this same type of cracking was noticed in so many different plants and under so many different conditions of installation and operation, the conclusion could be reached that there was some factor other than those mentioned which was responsible.

FIBER STRESSES AT SEAMS

As such a factor the question occurs at once as to the possibility of fault in construction. Of what magnitude are the stresses, both average and fiber, at the seams of a boiler, and in what measure is the material fitted to resist them? The material specified for boiler plate must have a tensile strength of from 55,000 to 65,000 lb. per square inch, and in modern boilers the construction is such that the average stress over the weakest section is about one-fifth of the ultimate strength, or, in other words, there is calculated to be a factor of safety of about five.

However, this factor of safety is probably fictitious only as several features in boiler operation and construction combine to lower it.

1. It has been shown by Rudeloff,¹¹ Martens¹² and others that although the ultimate strength of mild steel of the kind used in boiler plate is from 25 per cent to 35 per cent greater at the boiler operating temperature of 200 deg. C. than at ordinary temperatures, the yield point is about 15 per cent, the true limit of elasticity

25 per cent, and the elongation as much as 50 per cent lower than at ordinary temperatures; there is, in other words, a marked decrease in toughness at this temperature.

2. The fiber stresses at the seams of boiler plates have been shown^{13, 14} to be from two to four times the average stresses, a fact which is more significant when these stresses are not purely static ones.

3. Heyn has made calculations of the stresses in boiler plate due to the variation in temperature across the plate section and finds that fiber stresses of from 10,000-30,000 lb. per square inch are possible.

Considering then the whole situation it is not improbable that the actual factor of safety at the seams in boiler plate design is not much above two.

FORMATION AND EFFECT OF SODIUM HYDROXIDE AT SEAM

The above considerations have been developed not as a possible cause and explanation for the trouble described, but merely to show that it might be quite possible that some slight flaw or some slight deterioration in the material could be the "straw that broke the camel's back," and that it is by no means necessary to seek to find some very marked or acute destructive factor in order to have a complete explanation for the phenomenon in question. That there was, however, an added factor in the situation is scarcely to be doubted, and that this factor is the embrittling action of aqueous sodium hydroxide is believed to have the weight of evidence.

Of interest is a consideration of the exact manner in which the material at the seams of boilers becomes actually subjected to the action of alkali. The reasoning leading up to the study of the action of alkali on steel is due, as mentioned above, to Prof. S. W. Parr.

One of the most prominent cases in which cracking of the plate of the sort above described had been noticed was in the power plant of the Solvay Process Company at Syracuse, and particularly in the caustic soda department. It was also discovered that in that locality around and near Champaign, where this difficulty had always been noticed, the feed water, which was fed untreated, contained sodium carbonate in very marked proportions, the feed water at the university, for instance, containing about 70 parts in a million. Now sodium carbonate has a very appreciable dissociation pressure of carbon dioxide at boiling temperature, and loses, according to Kuestner and Grueters,¹⁵ 10 per cent of CO₂ in eleven hours if hydrogen is passed through the boiling solution. Sodium hydroxide will, therefore, under boiler conditions, be very rapidly formed from the carbonate, since the CO₂ can there very rapidly escape and equilibrium can never be reached. This conclusion was tested very simply by analyzing the water in several of the boilers, the results showing that from 50 per cent to 65 per cent of the sodium was present as the hydroxide, the amount of sodium hydroxide reaching as much as 400 parts per million—i.e., 1/100 N.

Sodium hydroxide of these low concentrations can have as above mentioned no appreciable effect on the mechanical properties of steel, but if this solution gets into the seams of the boiler and concentrates by leakage outward, solutions of caustic alkali of 50 per cent and more could easily be formed, and it is the action of such solutions which has been mainly investigated in this work.

There are certain questions which arise at this point.

First—How does the alkali get into the seams in the

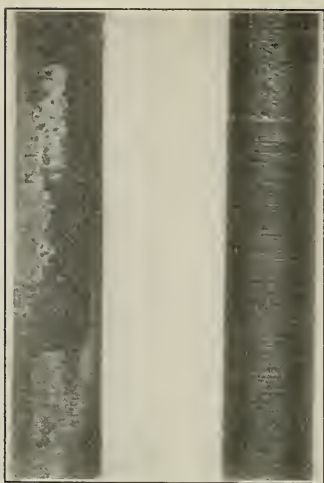


FIG. 12—THE CORROSION OF 1/4-IN. STEEL WIRE

A—After one week in 13.6 N NaOH at 280° C.

B—After one week in { 13.6 N NaOH }
{ 13.6 N Na₂Cr₂O₇ }

¹¹Stahl und Eisen, 1895.

¹²Stahl und Eisen, 1890.

¹³Leon, Österreichische Wochenschrift für den öffentlichen Bauwesen, 1909.

¹⁴Burracough, Engineering News, Vol. 69.

¹⁵B.T. 1905, 748.

first place, since the initial concentration is so small—N/100—that no corrosion takes place at ordinary temperatures. It has been, however, shown that N/10 sodium hydroxide corrodes steel at 200 deg. in two weeks very noticeably, so it may not be expected that solutions which inhibit corrosion at ordinary temperatures also do so at the higher ones. Further the passivity of iron in alkali of these low concentrations is diminished by the presence of chloride, etc., to be found in ordinary boiler waters, such that corrosion may very possibly go on even at these low OH concentrations.

Second—Generally throughout the country boiler compounds, many of which have as a primary constituent Na_2CO_3 , are being constantly used, without the impression having been gained that such compounds are in the least dangerous, whereas it would seem from the above that water treated in that way would have the same effect on boilers as the water with natural Na_2CO_3 present. It can only be pointed out in reply that persistent over-treatment would be necessary, since an excess of Na_2CO_3 over that amount required to precipitate the alkaline earth and heavy metals, calcium, magnesium and iron is required for the formation of sodium hydroxide. Further there is the not too remote possibility that the action of alkali is inhibited by other chemicals, which may be present in such waters, in the same way that sodium dichromate does. Some attention must in this connection be paid to the complication of the curious "recovery" of material after a certain time in contact with hydroxide. Finally it must be borne in mind, in considering why all boiler compounds containing alkali carbonates are not productive of failures, that the deterioration produced by alkalis is only one factor in a very complex situation, and that in order that failure may result these factors must combine toward this end.

EFFECT OF TREATMENT OF STEEL WITH SODIUM CARBONATE AND BOILER INCRUSTATION FROM FAILED BOILERS

It is interesting in this connection to consider the results of the treatment at high temperatures of steel with sodium carbonate solution, and with a solution made up with the boiler scale or incrustation which oozes through at the seams, responsible for the effect. Specimens were sealed up in the same way as with the alkali with concentrated solutions of Na_2CO_3 , and with concentrated solutions of the scale formed and put in the furnace together with the others. It was not expected that either of them would even corrode the steel since measurements of the emf. of the steel at 100 deg. C. to these solutions had give values to $\text{Hg} \cdot \text{HgO} \cdot \text{N} \cdot 10$ sodium hydroxide of about 0.135 for Na_2CO_3 , and +0.125 for the scale, which are only slightly above the critical values (+0.100) established by Heyn¹ as the limiting ones below which no corrosion of steel takes place at ordinary temperatures. This was only partially borne out by experiment, as the specimens were corroded after over a week's treatment in these solutions at the two higher temperatures, this corrosion being slight in the case of the carbonate, and fairly well marked in the case of the boiler scale. Hydrogen was found present upon opening the Na_2CO_3 pipes from the 180-deg. treatment only, but the action of the solution of the scale was accompanied by evolution of this gas. The results of the physical tests on the specimens treated with these substances (see Table I) show that the former has no effect, while the latter causes a very definite deterioration in the mechanical properties of steel. This was not understood until an analysis of this scale showed the presence of from 1 to 5 per cent of sodium hydroxide, which had been prevented from changing to the car-

bonate in the air by inclosure in oil, which was also present. As this scale used had actually been taken from the caps and seams, and was found to produce a deterioration in the steel samples analogous to that produced by sodium hydroxide it is considered that these results go far toward linking up the practical boiler failure situation with the experiments which have been made on steel of boiler plate composition.

CONCLUSION

It has been shown that alkaline solutions, such as those of NaOH act upon steel of low carbon content at higher temperatures in such a way as to produce brittleness of the steel as indicated by the alternating stress and the impact test, not noticeable in the tensile test however. This brittleness is probably due to the absorption of "nascent" hydrogen by the steel forming a less ductile or tough "alloy" with the hydrogen; it is relieved by annealing even at low temperatures. The effect of alkalis on steel is discussed in relation to the failures of boiler plates at the seams, occurring in localities where the water contains sodium carbonate; it is believed that these failures are due, at least in part, to this effect.

If such be the case, the elimination of such failures resolves itself into the question of the elimination of the alkali from the boiler water, or at least from the seams of the boiler. This could be done by the addition of ferrous or magnesium sulphates which would precipitate the carbonate or hydroxide in the water. It is also shown that the action of the alkali is to a large extent inhibited by the presence of sodium chromate, such that this substance could be advantageously used as an addition to alkaline boiler waters exercising this effect on the seams of the boiler plate.

Grain Size Determination and Standardization

By Zay Jeffries

In the April 1, 1917, issue of "Metallurgical and Chemical Engineering," page 378, Mr. George A. Miller, Jr., outlines a new adaptation of the comparison method for estimating grain size in metals. His ideas should be very welcome to metallographists.

In a paper before the Faraday Society, presented May 9, 1916, entitled "Grain Sized Measurements in Metals and Importance of Such Information," I have written as follows regarding the general method which Mr. Miller recommends:

"ESTIMATION OF GRAIN SIZE OF UNKNOWN BY COMPARISON WITH KNOWN SAMPLES.—This method is used by C. Grard¹ for controlling the work and annealing of copper and brasses. He first prepared a set of samples, treated mechanically and thermally under known conditions, and takes micrographs at certain suitable magnifications. The initial set of known samples should include all of the ranges of mechanical working and heat-treatment which will be encountered in practice. By taking an unknown sample and comparing its structure with that of the set of knowns, it is classified according to the size and the shape of the grains. In this way there need be no attempt to determine the number of grains per unit of area, as the relative number of grains may be all the information desired.

The control of carbon and phosphorus in certain iron and steel products will be recognized as a comparative method of grain-size determination. These determinations are made macroscopically on the fractures of the samples, and it is surprising how closely the carbon or phosphorus content can be estimated in this manner. The comparison method is the most flexible of all the methods, since it can be used to compare structures of all kinds."

¹"Industrial Application of Microscopic Metallography for Controlling the Work Put on Copper and Brasses," International Association for Testing Materials, Sixth Congress, New York, 1912.

¹Mitt. Kgl. Materialprüfungsamt, 1908.

The ingenious manner in which Mr. Miller applies this method should not only make the comparisons more rapid, but should eliminate to a large degree the fatigue of the operator, which is one of the greatest drawbacks to any counting method. I think the comparison method as applied by Mr. Miller can be used for grain size estimations in metals and alloys other than brass. This method can be used in practically any field where grain size determinations in large numbers have been adopted as a matter of routine. It can also be used as a method of estimating the quantity of any given metallographic constituent, after the standards have been properly prepared.

The limitations of the comparison method should be indicated. A great amount of work is necessary for the proper preparation of the known samples. If only a few grain size determinations are desired it is doubtful whether the preparation of a set of standards is justifiable. Also samples will occasionally be encountered which have grain sizes outside the limits of the standards.

Where the number of grain size determinations is few or even for determining the grain size in the standard samples the following method³ will be found both rapid and accurate.

This determination is made by projecting the image of the sample on to a screen or a ground glass and counting the grains intersected by the circumference of a circle of standard diameter, which is drawn on the screen or the ground glass and then counting the grains which are completely included within the circle. Referring to the boundary grains as w and the grains which are completely enclosed within the circle as z , the equivalent number of grains within the circle is

$$z + yw$$

where y is a factor which has been determined empirically on a large number of samples. This factor is 0.6. The size of the circle is so related to the magnification that the equivalent number of whole grains within the circle when multiplied by a whole number such as 100, 50 or 10 will give the number of grains per square millimeter on the samples.

It should be kept in mind that one of the chief advantages of the microscope lies in the fact that quick tests for uniformity either in grain size or composition can be made by its use. In order to test for uniformity of structure I usually make determinations at 5 points across a diameter of the sample. The results of each grain size determination are not known until after the determination is completed, that is, after the counts are made. In this manner a fair sample of the surface of the polished section of metal is obtained. When estimating grain size by the comparison method would not the operator unconsciously move the specimen slightly, for the last four determinations, so as to make the grain size compare as nearly as possible with the first determination? If this point is a factor, it is only of importance in samples which have appreciable grain size variations locally.

Regarding the numerical figures used to indicate the grain size there are two general systems.

1. Referring to grain size in terms of the number of grains per unit area, and

2. Referring to grain size in terms of the diameter of the average sized grain.

I have used the word "diameter" for want of a better word. In this place, it means the length of a side of a square having the same area as the average grain; it is the reciprocal of the square root of the number of grains per unit area.

It would be advisable to standardize the unit of reference. Below are outlined the chief arguments for and against area as the unit of reference.

Arguments in favor of area as the unit for grain size reference:

1. The section which is being examined for grain size is an area, not a line.

2. All accurate direct grain size measurements are based on the determination of the number of grains exposed on a certain area.³ The arithmetical operation of finding the reciprocal of the square root of the number of grains per unit area is a necessary step to obtain the diameter of the average grain.

3. The number of grains in a certain area is the actual thing determined, while the mean grain diameter has no real physical existence.

4. Grain size is more often referred to in terms of area than in terms of "diameter."

5. It is always desirable to use whole numbers in place of decimals or fractions. For example, to avoid the general use of decimals and fractions new units have been coined, such as mil, micron, millimicron, millivolt, etc.

The list of grain sizes given by Mr. Miller as his standards would be changed as in Table I.

TABLE I.

Diameter of Average Grain in mm.	Grains per Sq. mm.
0.025	1600
0.030	1100
0.040	625
0.050	400
0.070	200
0.080	150
0.090	120
0.100	100
0.125	64
0.180	30

By using the figures in the second column in the comparison method no calculation is involved in the grain size estimations.

Arguments in favor of diameter as the unit for grain size reference:

1. A smaller number indicates smaller grains, whereas in the area reference scheme the numbers are larger as the grain size decreases.

2. The diameter method probably permits of a better mental conception of the size of a single grain.

The writer is in favor of area as the basis for grain size reference and the use of the sq. mm. as the unit. In most useful metals the number of grains per sq. mm. would be a whole number and not so large a number as to become burdensome. The finest grained sample I have examined showed 80,000 grains per sq. mm. All of Mr. Miller's standards fall between 30 and 1600 grains per sq. mm. If grain size determinations are desired on exceptionally coarse grained samples the unit can readily be changed to sq. cm. by multiplying the number of grains per sq. mm. by 100.

Case School of Applied Science,
Cleveland, Ohio.

³ The intercept method has been proved to be very inaccurate.

Annual Meeting of Chemists' Club

The annual meeting of the resident members of the Chemists' Club, New York City, for the election of officers and the transaction of other business, will be held on Wednesday, May 2 at 8 p. m. Interesting announcements will be made and refreshments and entertainment will be provided.

³ Trans. Am. Inst. Min. Eng., Vol. LIV, p. 594.

The Japanese Chemical Industry New Enterprises Started in Japan Since the Outbreak of the War*

By PROFESSOR DR. H. NISHIDA

The great war has given the Japanese chemical industries a good opportunity for development. The following new enterprises, as reported by the Japanese Department of Agriculture and Commerce, are most important.

I. ARTIFICIAL DYESTUFFS

Until the war stopped importations from Europe, there was no artificial dyestuffs factory in Japan, with the exception of some pigment factories. The total amount of importations represents, therefore, directly the total demand of Japan. The figures of importations per year are as follows:

	Lb.
Aniline and alizarine colors.....	10,185,185
Artificial indigo	1,851,852
Total	12,037,037
Total price	\$4,000,000

As a result of cutting off this large amount of importations, chiefly from Germany, the Japanese dyestuff market has been extremely excited, with a very large rise of prices.

At the same time, a great many dyestuff factories have been established, the largest of which is The Nippon-Senryo-Seizo-Kabushiki Kwaisha (meaning the Japanese Dyestuff Manufacturing Co.). This is specially encouraged by Government protection. Most of the new plants have been short of capital, and have also suffered seriously from the lack of good chemical experts; for these reasons most have recently been closed down. On the other hand, the Tokyo Gas Company and the Mitsui Mining Company have been most successful comparatively and have placed their products on the market. As aniline oil and aniline salt were easiest to make, overproductions of these products has come about, beyond the home demand of Japan.

Among all dyestuffs, most attention has been paid to the sulphur dyestuffs on account of their ease of production. "Some makers used every organic waste for the raw material as that stage of the manufacture of 'Cachon de Laval,' the first member of the sulphur colors. Some others have used aromatic compound for the raw material, and got the final success, still continuing the production of the black and brown sulphur colors, although they do not care much about the purification of the product which seems to be quite unknown to those chemists."

The largest company, mentioned before, The Nippon-Senryo-Seizo-Kabushiki-Kwaisha (capital \$4,000,000), is now extremely busy finishing its equipment in order to start manufacturing in spring, 1917. When this company will begin to place its own products on our market the Japanese dye industry will be quite independent of foreign dyestuffs. But there are some who are doubtful and expect only a few colors to be placed on the market. When peace will be re-established the dyestuff-making industry in Japan will be certainly one of the most noticeable achievements of the period of war.

2. MEDICALS

Of medicals there are a great many varieties. The difficulty and complexity of manufacturing them have rendered the sound development of this industry difficult.

*From the first issue of *The Kwagaku Kogi* (*The Chemical Technology*), "a monthly journal of chemistry and chemical industry," edited by Prof. Dr. H. Nishida. The first issue contains 106 text pages, of which four pages are printed in English and 102 pages in Japanese. The figures of cost in the original article are given in yen (1 yen = 0.498 dollar). In converting the yens to dollars, 1 dollar has been assumed to equal 2 yens.

Nearly all pure drugs have been imported in the past to Japan from Germany. Furthermore, most Japanese physicians have been trained in German universities and they have been accustomed to use the German medicals as the best and most necessary source of their recipes. Just as in the case of dyestuffs, the Japanese government has decided to protect the development of a drug industry in Japan. It has instructed The Sanitary Examination Establishment in Tokyo and Osaka to try to manufacture the more important medicals. Up to now these two stations have certainly been successful in actually making morphine-hydrochloride, bisalcycilic acid, carbohic acid, bismuth, atropin sulphate and bi-compound, creosote, chloroform, codein phosphate, guaiacol, heroin-hydrochlorate, tannic acid and gallic acid, etc.

3. WOOD-DISTILLATION BY-PRODUCTS

Acetic Acid.—Since the new tariff went into force in 1911, the manufacture of acetic acid in Japan has obtained a very satisfactory position. By and by the Japanese home product has become of excellent purity and importations have almost ceased. As a result of the demand for it the price of acetic acid has increased to more than four times the normal price, and suddenly a quick increase of the capacity of production has become necessary. This has made it possible to export the products to the Oriental market as well as to England, the exports amounting to 1,468,333 lbs. in 1915, while the home demand of Japan was 1,984,127 lbs.

Calcium Acetate.—A great deal of acetate of lime, the raw material of acetic acid, has been imported to Japan from America, the importations amounting to 8,994,710 lbs. or more (\$276,500). After the outbreak of the war there was not only an increase in the demand for acetic acid, but for acetone in America, with the result that exportations of acetate of lime from America were reduced. The importation into Japan stopped in June, 1915, and the market price has increased to as much as three times the normal price. After this time, however, nearly all charcoal-makers entered into the manufacture of crude acetate of lime as a by-product, and now the price is becoming more moderate.

Formalin.—As the sole antiseptic agent in silk-sericulture, much formalin has been imported from America and Germany (1,000,000 lbs. annually). In Japan since 1911, from 26,000 to 35,000 lbs. have been monthly produced. After the outbreak of the war a considerable amount was still imported for a while. But gradually the supply became deficient and finally the Japanese government determined to protect the home industry. Under these circumstances the firm of Toyo-Yakuhin & Co. (meaning Oriental Medicament-Manufacturing Co.) was established for an annual production of 1,500,000 lbs. of formalin.

Methyl-alcohol.—Methyl-alcohol, the raw material of formalin, was produced in Japan only in an amount of about 300,000 lbs., which amount was always insufficient for 400,000 lbs. formalin. Recently the process of its manufacture has been improved and the output is said to have remarkably increased.

4. GLYCERINE

Formerly Japan imported about 1,000 tons of glycerine annually from England, America and Germany, while at home about 760 tons were produced. On the other hand, the demand for military and technical purposes increased very materially, and when after the outbreak of the war the export of glycerine was strictly forbidden from all belligerent countries, the price in Japan increased to 3 or 4 times the normal price.

As a result new plants for manufacturing glycerine

were established, among which the Nippon Glycerine-Kogyo Company (capital \$1,500,000) was formed under the protection of the Japanese government. This company has a plant capacity of 500 tons of purified glycerine, which will be soon increased to 1000 tons output.

5. GLASS

Exportations from Japan to India and Australia have been very successful, and more orders are arriving from all parts of the Oceanian countries and even from England. Among them, Indian bracelet as well as glass beads, medical bottles, toilet bottles, lamps, cups, dishes are in especially great demand. Japanese glass manufacturers have increased their capitalizations and equipments.

The home demand for plate glass in Japan has increased recently to as much as 500,000 cases, but as imports from Belgium, England and Germany have absolutely stopped, the price has gone up rapidly. The only maker of sheet glass in Japan, the Asahi-Glass Manufacturing Company, has quickly increased its capacity, but the demand from abroad has also increased. China, Australia, India, Oceanian countries, South America are new trade markets for Japanese sheet glass. The said company is now busy preparing further extensions for the production of 700,000 cases annually and for the home production of the soda-ash, which is a most important raw material for the glass. Thick plate glass is now being made on an experimental scale by the Asahi Glass Manufacturing Company and by the Union Glass Co. The results obtained are said to have been very good.

5A. CELLULOSE

Cellulose manufacturing in Japan had a very miserable experience until the end of 1913. There was overproduction by the two big factories, the output being greater than the Japanese home demand and only a few novelty articles being exported. Since the outbreak of the war, the Nippon Cellulose and Artificial Silk Co., Aboshi, has given up the manufacture of cellulose and has begun to make gun cotton for Russia. At the same time exports of cellulose from Germany diminished considerably, while the demand for cellulose sheets quickly increased.

The only large cellulose manufacturer in Japan at the present time, the Sakai-Cellulose Co., is now extremely busy exporting its products to England, France, Russia, America, Australia, India, South Sea Islands, China and other countries. The increase in the manufacturing capacity of this company has not been sufficient to meet the demand.

The most important novelty articles of cellulose are household tools, combs, brushes, toys, "hangings," etc., \$1,500,000 worth of these were manufactured in Japan in 1915, which is over twice the amount of the preceding year.

6. PAPERS.

Even before the war the Japanese paper industry had an enormous development. The Japanese home production of printing paper, writing paper, drawing paper, packing paper, amounted to 167,000 tons in 1913. Still better kinds of printing paper, drawing paper, writing paper were imported to the extent of about 37,000 tons. The outbreak of the war cut off these imports and the demand for paper in the Chinese market produced most flourishing times for every Japanese paper mill. Successful extensions of the mills were carried out and about 210,000 tons are said to have been the output during 1915.

Furthermore, the export of paper from Japan has

also increased about three times. The manufacture of filter paper, which was not manufactured in Japan, has recently been started at Kochi.

It has lately become the practice in Japan to mix chemical wood pulp with Japanese best fibres. The sudden increase of the price of the raw materials has seriously affected the small paper makers. But by and by they are going to recover their fortune.

7. PULP.

Japan's annual demand of wood pulp is said to be about 120,000 tons, one-third of which used to be imported from Germany and Sweden. As this importation has stopped, the price has awfully increased. On the other hand, the price of paper at the time of the outbreak of the war was rather low, so that most paper mills using wood pulp have suffered greatly.

Of the total demand, about 60,000 tons are ground pulp, the rest being sulphite pulp. Of the former Japan does not want any importation, while of the latter she still wants to import about 40,000 tons. Lately many wood pulp mills at home have increased their capacity, so that after peace will be reestablished Japan will no more have any difficulties in the production of the desired amount of pulp.

8. PHOSPHORUS.

Japan's home demand of phosphorus has been 7000 cases (each of 100 lb.). These have been imported from France, England and Germany, 60 per cent being red phosphorus, 40 per cent yellow phosphorus. Before the war Japan had only two phosphorus factories, the Denro-Kogyo Co. (meaning Electric Furnace Co.) and the Fuji-Denkwa Co. (meaning Fuji Electro-Chemical Co.), both in the Shizuoka district. The output of these two factories were only 17 per cent of the total importation, so that match manufacturers got scared when war was declared.

The price was also enormously raised, to about \$250 (5.5 times the normal price) per case of red phosphorus, and \$200 (6 times the normal price) for yellow phosphorus.

This resulted in big extension of the above mentioned companies. The Denro-Kogyo Co. was amalgamated with the Nippon-Kwagaku-Kogyo Co. (meaning the Nippon Chemical Industry Co.), and the other company erected branch stations. At the same time a new company, the Tokyo-Denkwa-Kogyo Co. (meaning Tokyo Electro-Chemical Co.), was formed. The total output has thus reached 3700 cases, which is still less than half of the total home demand. So they are said to have made further extensions quite recently. At present the raw phosphorus ore is at an extraordinary price, but the price of the manufactured phosphorus also is high. Nevertheless, after peace is restored, the management of these plants will require most careful attention.

9. POTASSIUM CHLORATE.

Formerly the annual demand in Japan was 4000 tons, of which 1000 tons were made in Japan and 3000 tons were imported. After the outbreak of the war the export of matches has still continued in good condition notwithstanding the shutting off of the importations of chlorate of potassium from Germany, France, England and Switzerland. The price of this raw material once reached \$90 per barrel (112 lb.), while the former price was only \$8. At present a great many plants have been established for this purpose, and old factories have increased their capacity, and still the activity continues. There is ground for pessimistic fears as to an overproduction in the near future.

Oxidation and Reduction in Physical Chemistry—Consistency of Terms and Conceptions

By Carl Hering

In the Dec. 1 issue of this journal, page 649, the writer pointed out the inadequacy and inconsistency of some chemical terms which give rise to confusion, and suggested some reforms and remedies which would clarify matters and would lead to consistency and to concordant results. The purpose of the present article is to show that certain disputed and discordant conceptions in physical chemistry concerning oxidation and reduction can be systematized and brought into complete concordance when they are consistently interpreted.

The kind of chemical reactions commonly called reduction and oxidation, which are the direct opposites of each other, would embrace all the primary electrochemical reactions, and no doubt many purely chemical ones also, if the scope of these terms were applied more consistently to all the physical processes which are of identically the same nature, by extending their application in some ways and limiting them in others, instead of as at present limiting them by looseness of expressions and meanings to only particular ones of what are physically the same processes, and inconsistently applying them to others; this was touched upon in the previous article. The adoption of these more consistent and systematized meanings and conceptions would greatly simplify the study of the subject by students and cannot fail being of assistance or at least of interest to the professional electrochemist or chemist; it surely leads to clearness by avoiding ambiguities. Science is defined as classified knowledge—that is, knowledge which has been arranged in an orderly and systematic way; this systematizing of the scope of these terms would help to make order.

Reduction and oxidation being admittedly physically the same process, differing only in their sign or direction, and the processes terminating at the cathode and anode being also direct opposites though the same in kind, it follows that when it is said that the hydrogen which is set free from water at the cathode has been *reduced*, the oxygen set free at the anode must necessarily be said to have been *oxidized*, in order to be consistent; it would in fact be not only looseness but even physically wrong to say that the oxygen had thereby been reduced. To call it oxidation is not common practice to-day, but consistency and systematizing demand that the meaning of this term should be broadened to include all the processes which are the direct opposites of reduction. This consistency simplifies the conceptions of these processes and systematizes them, as will be shown below. That the oxygen has thereby been "oxidized" is not irrational, as its oxidizing action has then been increased, free oxygen having a stronger oxidizing power than when combined.

Similarly, when a metal combines with free oxygen it is correctly said to be oxidized, but the oxygen itself must necessarily be said to have been reduced in that process. This also is not common practice to-day, but consistency and systematizing demand this broadening of the term reduction in preference to introducing a new term. The oxidizing power of the oxygen has thereby been reduced.

Hence in general when two elements combine or are separated by processes ordinarily termed oxidation and reduction, the process defined with respect to one of them must always be the exact reverse of the process defined with respect to the other. Thus when H₂ and S

combine, the H is being oxidized and the S is in fact being reduced to a lower degree even than free S; and when again separated the reverse is true. This, of course, applies likewise to combinations of other elements than oxygen and to radicals like SO₂.

In a general sense to aid the student, it may be said that oxidation generally consists in combining two or more elements to form a compound, or mathematically expressed, in the chemical addition of an element to another, while reduction, the reverse process, generally consists in separating them again, or mathematically expressed, in the chemical subtraction of an element from another. Physically, therefore, oxidation is in general of an additive nature or a gaining, while reduction is of a subtractive nature or a loss. This, however, is only a "guide to the memory" to what follows below, for it is evident that when H and O, for instance, are freed by separation (subtraction), the H being thereby reduced, the O must be said to be oxidized, as explained above; but, as will be shown below, this oxidation consists really in the addition of valence, and according to the writer's view an addition of electric charges, and is additive for those reasons.

The same is true of the bonds; reduction implies in a general way a reduction or loss of bonds, a breaking of them, and oxidation a gain of them or a making of them. But this again is only a general guide to the memory, for in the "oxidation" of oxygen by freeing it from H₂O there is a loss of the bond, though this loss is really the result of an *addition* to or an increase of a negative valence; thus the addition of 2 to -2 equals zero—that is, nothing—a free element having no bonds and therefore no valence while in that state. An estate owing \$10,000 is worth nothing after \$10,000 has been added to it.

All electrochemical oxidations and reductions consist in the changing of the valences, and therefore result in the making and breaking of chemical bonds; it can be shown that electrolytic reductions are always a reduction of the valences, while oxidations are always an increase of the valences. Bonds and valences are therefore closely allied, though they should not be considered the same thing, as is done by some authors, because the number of bonds depends not only on the valence, but also on the number of atoms; thus in Na₂SO₄, the valence of Na is 1 and of O is 2, but the Na has two bonds and the O has eight.

All bonds being positive with respect to one element and negative with respect to the other to which it is bonded, it necessarily follows that valences must have + and - signs also, and as a free element has no bonds, its valence must of course then be zero. This was explained more fully in the earlier article cited above. Compounds which are not ionized have no free charges, which means that their positive and negative charges are equal, and it is supposed that the force holding the elements together is caused in some way by the attraction of these charges to each other.

Chemical reduction being therefore always accompanied by a *loss* of valence and in a general way by a *loss* of bonds and a *loss* of a companion element, and oxidation by a *gain* of valence, and in a general way by a *gain* of bonds and a *gain* of a companion element, consistency would indicate that probably modern theories would show that reduction also means a *loss* of negative electric charges and oxidation a *gain*. Some writers, however, claim that it is the reverse of this, which would be an unfortunate break in consistency if it were really definitely proved by facts, as distinguished from arguments involving definitions about which there is doubt or disagreement. It would, in fact, be so desirable, not only for the benefit of the student but also to

systematize our conceptions, to establish this consistency, that there would seem to be justification for defining terms now having a doubtful meaning in such a way as to bring about this much desired consistency and concordance, assuming, of course, that the result is not at variance with the true facts, and the writer has not been able to obtain from the advocates of the "prevalent" view any positive proof that oxidation is physically really a loss of negative electrons. Until the latter has been established physically as distinguished from deductions from ill-defined or incomplete conceptions, the following analysis and strict definitions are believed to show that the desired concordance seems to be true, and could therefore be used until the contrary has been definitely established by proof.

It is known and apparently not disputed that at least with electrolytes every unit of valence represents a charge of one faraday (96,494 coulombs or 26.80 ampere-hours) and that reduction is a loss of valence, hence a loss of these charges, while oxidation is a gain of valence or charges. So far, therefore, the gain and loss of charges are consistent with the gain and loss in other respects. This does not specify, however, whether these charges are positive or negative.

According to our older conceptions it is the positive electricity which flows in the direction of the conventional arrow, hence a loss of a charge means that it was a positive one. The older conception also states that the cation is reduced at the cathode, to which it gives off its positive charge, which then passes off as the electric current, after which the freed element is neutral again. The current enters the electrolyte at the anode, from which the positive charges are received by the anions, thereby neutralizing their negative charges and freeing them. Hence, according to these older and simpler conceptions, reduction is accompanied by a loss of charge and oxidation by a gain; this is consistent with the above.

But the modern electron theory says that it is the negative electrons which move in the opposite direction, hence it follows that a loss of a charge would mean that it was a negative one. And the modern dissociation theory states that the dissociation of a compound into its ions occurs while it is being dissolved, hence before any current is applied, it therefore does not occur at the electrodes as was formerly believed.

Solid, electrically neutral NaCl, for instance, when dissolved in water, dissociates in part at once, without a current, into Na ions and Cl ions, hence the actual separation occurs then; the bond which combined them is thereby broken, it then no longer exists, as these ions then are separate molecules. The very word "dissociation" means separation into component parts; by saying that steam is dissociated by a high temperature is meant separating it into H₂ and O; that is, breaking the bond.

Oxidation and reduction considered physically involve the making and breaking of bonds, hence it is at the moment when these are made or broken that the process of oxidation and reduction really takes place. Dissociation is a breaking of these bonds, hence the actual reduction of the cation occurs during the dissociation process, and as was shown above, while one ion of a compound is being reduced, the other, undergoing the reverse process, must be said to be undergoing oxidation, in the broad sense that it is the reverse of reduction; hence true oxidation also occurs during dissociation.

It is true that the ions produced by dissociation are then not yet completely freed; the Na and Cl in dissociated NaCl are not yet free Na and free Cl; they are still held by their charges in some way which is perhaps

not yet clearly understood; but it is sure that they at least have had their chemical union broken, which is what the word dissociation means, and it is this part of the whole freeing process which, to be consistent, must be called the real reduction process; chemical reduction often does not mean complete freeing, as, for instance, in reducing ferric to ferrous salts, yet it is physically and by definition a true reduction; freeing an element is therefore not an essential attribute of reduction; reduction is only a step toward freeing an element. Oxidation can also free an element, as was explained above, but freeing it is not an essential attribute of oxidation.

According to the now generally accepted dissociation theory, therefore, and using the words reduction and oxidation in what seems to be their rational and consistent sense, the ions are reduced and oxidized during dissociation, and it is only after this and not before that the cations have the so-called free positive charges and the anions the free negative charges; it is important to note that it is only the dissociated elements and not those which are still combined that have these charges—those that are still combined are neutral. It is said, for instance, in a colloquial way, when free H has been oxidized by free Cl to HCl, that it then has a positive charge, because it is generally so marked. This, in the writer's opinion, is a misinterpretation of what appear to be the real facts, and leads to great confusion. The H in HCl, which has a positive charge, is only that fractional part of the total which has *subsequently* been dissociated again from the HCl, and which in thus being reduced again has lost a negative charge; the H which is left in the solid HCl, or that which still remains combined as HCl in the dissolved though undissociated salt, has no free charge.

According to J. J. Thomson, the father of the electronic theory, "An atom plus an electron is a monovalent anion; an atom minus an electron, a monovalent cation." As the cation is that ion which *has been* reduced by the dissociation, and as the word electron here means negative electricity, it follows again that reduction is accompanied by a loss of negative electrons and oxidation by a gain.

Hence during the real process of reduction the cations must have *lost* negative charges because they are known to have free positive charges left, and during the accompanying real process of oxidation the anions must have *gained* negative charges, because they are known to have free negative charges thereafter. This, therefore, again agrees with what was said above concerning loss and gain of valence, bonds and companion elements, thereby showing perfect consistency and concordance throughout.

It is said that the iron in ferric sulphate, for instance, has three positive charges, often indicated by three + signs over it, and that in ferrous sulphate it has two positive charges; in a colloquial way it is said that *therefore* when ferric iron is reduced to ferrous it has gained a negative charge, hence that *reduction* is a *gain* of negative charges, the contrary to the above. This deduction, however, the writer maintains is incorrect; the iron thus marked in the ferric salt represents that which *has been* dissociated to iron from its compound, and therefore *has been* reduced, during which reduction it has *lost* three negative charges, as it has three positive ones left; before this reduction by dissociation—that is, while still combined—it had no free charges, hence the very fact that it now has three shows that it *has been* reduced.

In the writer's opinion it is therefore not correct to say (as has been done by some authors) that the iron in the ferric solution, in which it is marked as having

three + charges, has gained a negative charge (lost a positive one) by being reduced to the ferrous state, in which it is marked as having only two + charges. In formulas thus marked both are now the same reduced ionized iron and therefore are alike as such, both having been reduced to the same unoxidized iron from their respective combinations by dissociation, which is assumed to have taken place then or they would have no charges; neither can now be said to have been reduced or oxidized from the other; the charges marked on them represent their *previous* history as it were, and not their present state of oxidation, the one having lost three negative charges when it was dissociated (reduced) to iron from the ferric salt, and the other having lost two negative charges when it was dissociated (reduced) to iron from the ferrous salt.

While both of these ions are therefore alike in being ionized (reduced) iron, there is still left the difference that the one carries three positive charges and the other two; but this difference is a result of the real reduction (breaking of the bonds) as explained above, and any subsequent process like the completion of the freeing by neutralizing these charges with a current is not a part of the real reduction when that term is consistently defined; it is physically something else than reduction, to which perhaps no name has yet been given; it might properly be called the neutralization or freeing of the charges, but not oxidation and reduction. If in a colloquial way this final freeing of the dissociated ions has been referred to as the real reduction and oxidation (and this is implied or even directly stated in some textbooks), it is surely inconsistent and therefore, in the opinion of the writer, should be corrected. When the iron in a ferric solution has been reduced to ferrous, a real and physically perfect process of reduction, complete in itself, has taken place, of which the final freeing of this iron is not an essential part.

The controversy may be said to lie in the definition of the term reduction; if it is defined consistently as always applying to that physical process in which the bond joining two elements is broken, as recommended in this article, then everything is brought into complete concordance and agreement, but if it is defined as applying sometimes to this and sometimes to the process of setting free an element which has already been separated from its combination, or dissociated as it is more frequently called, then looseness of meaning, discordance, inconsistency, confusion and lack of uniformity result. It is then like a series of gear wheels which should all mesh together for a common end, but in which one of the wheels is "out of gear" or "out of mesh" with all of the others.

For a long while it satisfied chemists to represent water as HO, and it satisfied the people to say that the sun moved around the earth; but to-day these and many other conceptions which were "universally accepted" in former times have been discarded for better ones.

Even if a direct physical demonstration, as distinguished from an argument based on loose definitions, would show beyond question that oxidation is always accompanied by a loss of negative electrons, yet to bring about concordance which is so helpful to the student, and in view of the fact that the + and - signs and the conventional arrow are still in common use, indicating a flow of current from + to -, the writer would still advocate saying that oxidation is a "gain of charges" (+ charges in that case) and adding the explanation which must to-day also be added in numerous other cases, that it is really the negative electrons which move in the reverse direction, just as we still say that the sun "rises" in the east, with an explanation when necessary. Electrolytic reduction would then have to be ex-

plained as taking place at the cathode and not during dissociation, though this would involve unfortunate inconsistencies which tend to confuse the student.

As the term "reduction" implies a subtraction, hence a loss, it is an appropriate one to be applied to a loss of valence, charge, bonds and companion elements. But the term "oxidation" is not an appropriate one for the reverse and is acknowledged to be inconsistent in that it is applied to combinations with other elements than oxygen. It is for this as well as for the additive features given above that the writer favors the new word "adduction" for the exact reverse of reduction. Since the former article was published, the writer found that this term had already been suggested for similar reasons by Dr. M. L. Hamlin in an article by Nelson and Falk, *Journal American Chemical Society* 35, December, 1913, page 1812.

Philadelphia, Pa.

Manufacture of Pig Iron in the Electric Furnace at Domnarfvet, Sweden

The large Helfenstein electric furnace at Domnarfvet, Sweden, which was started in May, 1913, and a new one under construction, are the subject of a discussion in (*London*) *Iron and Coal Trades Review*, Feb. 23, 1917. A review of an article on these furnaces in *Stahl und Eisen*, by Dr. Max Oesterreich of Vienna, forms the basis of the discussion, which is as follows:

"The original furnace used three-phase current and had three top electrodes. It was inspected in 1914 by Dr. A. Stansfield of the Canadian Department of Mines, and was stated to be still in the experimental stage at that time and very little information was given out. The article by Dr. Oesterreich gives the results of the working with soft charcoal for a week in June, 1913, when certain breakdowns were occurring.

"The maximum output in twenty-four hours was 65 tons, the monthly total varying between 1000 and 1500 tons of pig iron, "according to the available amount of electric energy and the quality of the ores." For a longer period of working with charcoal as a reducing agent, the following average consumptions are given per ton of pig iron:

Energy consumed (60 per cent ore), 2170 kw.-hr.

Charcoal (70 per cent C.), 380 kg.

Electrodes, 5 kg.

When working experimentally with coke the average rates of consumption per ton of pig iron were as follows:

Energy consumed, 2600 to 2700 kw.-hr.

Coke, 310 to 330 kg.

Electrodes, 4 kg.

"At the same time the author makes the statement that the consumption of electrodes has now been reduced to 2 kg. per ton of pig iron, a figure, we are told, so low that it has not yet been beaten by any other furnace.

"The trial working with coke did not last long enough to enable one to form a definite opinion, but the results were, nevertheless, encouraging, so much so that a Helfenstein electric low-shaft furnace is now in course of construction in Norway, and is to start work in 1917. In the construction of this plant special attention is being paid to the rational production and utilization of the furnace gases. The new plant is to demonstrate the superiority of electric smelting of iron ores over the old blast furnaces, and not the high-shaft electric furnace, in all situations where electric energy is cheap and coke is expensive. According to the author, the hp.-year yields an output of 2.4 tons of pig iron with coke as a reducing agent in the electric furnace, and there is a saving of 1.63 tons of coke per hp.-year compared with

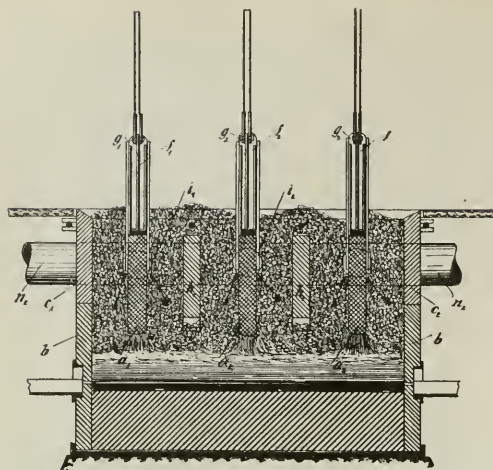


FIG. 1—LONGITUDINAL SECTION OF MULTIPLE-HEARTH FURNACE

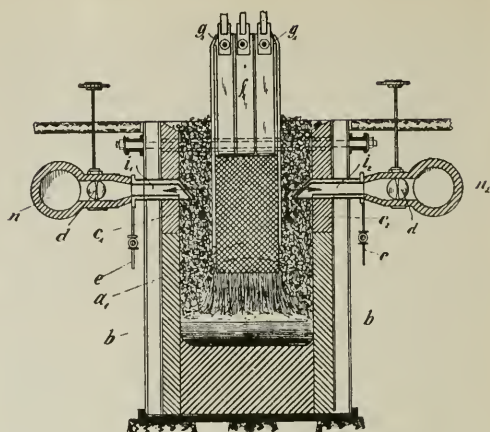


FIG. 2—CROSS SECTION THROUGH PLANE OF ONE ELECTRODE

ordinary blast-furnace working. Hence, wherever the hp.-year costs less than 1.68 tons of coke, an electric furnace would be preferable to an ordinary blast furnace from the point of view of working expenses. In checking the author's figures, it will be found that 2.4 tons of pig iron smelted in the electric furnace require 768 kg. of coke, which added to the saving of 1.68 tons, represents a consumption of 2.448 tons of coke to produce 2.4 tons of pig iron in the ordinary blast furnace, which is a fair figure, considering the high grade of the ore. The cost of the electrodes has been purposely disregarded, as it should be more than compensated by the saving of interest on the reduction in the first cost of the installation, and by savings in other directions.

"The building for housing the Helfenstein furnace at Domnarfvet has been made 8 metres (26 ft. 3 in.) higher than would have been necessary, as it is to accommodate also a Grönwall furnace. For a low-shaft furnace alone a height of 16 metres (52 ft. 6 in.), including the depth of the bins for storing materials, would have been ample. The furnace can be tapped on either side. Besides the large furnace a smaller one of 400 to 500-hp., constructed as a low-shaft furnace on the same principle, is also used for experimentainga and testing purposes.

"The main new fact now told is that of the seven men formerly in attendance on (what was intended to be) a 10,000-hp. furnace (three for tapping, one attending to the regulators, and three chargers), two of the last mentioned can now be spared, since cranes have been provided for charging the furnace, which is being worked with a mixture of charcoal and coke at a reduced voltage developing 5500 hp. only as a consequence."

The original article of Dr. Oesterreich contained seven illustrations, but as *Stahl und Eisen* is not available in this country, and none was included in the above review, we are unable to reproduce any of them.

A patent on one type of furnace has, however, just been issued in this country to Mr. Alois Helfenstein (1,223,278, April 17, 1917), and assigned by him to the Union Carbide Company. The Helfenstein furnace was first used for calcium carbide and ferrosilicon, but was later (starting in 1912) adapted to iron ores. The furnace has been described in our Vol. VIII, p. 46 (1910) and Vol. X, p. 658 (1912) by Dr. R. Taussig, and also

in abstracts of patents in various issues of this journal.

The present patent was applied for in June, 1914, and describes a multiple-hearth electric furnace, the chief feature of which is the common charging column for all electrodes, which does away with separate bells and hoppers. A longitudinal section of the furnace is shown in Fig. 1 and an end section in Fig. 2.

It is stated that in furnaces intended for large outputs the arrangement of a charging bell and hopper around every electrode interferes with the efficient working of the furnace. Consequently the electrodes are served by a common charging column. This also makes possible a more effective disposal of the furnace gases. In the figures a_1, a_2, a_3 are three electrodes, b is the common reaction shaft and c_1, c_2 is the common charging shaft. Between every two reaction hearths is arranged a partition wall $h_1, \text{ or } h_2$, consisting of a fireproof girth. These are to prevent current leakage from one electrode to the other. The gas is drawn off through tubes i_1, i_2 , provided with water jackets and regulated by valves.

"The collected gases pass over into the conduits n, n_1 , which, according to the process, may serve also as combustion or as condensation pipes, or they may be constructed in such a manner that the gases are conducted away through the same without being burned, or that they are burned in the presence of or together with a suitable supply of air.

"The furnace is intended especially for the production of heavy metals, alloys having iron as a component and volatile metals and their oxides, such as zinc.

"The height of the charging shaft extension depends, of course, upon the process, especially, however, upon whether or not pulverulent or granulated material is made use of.

"The height should also be such as is necessary for packing the openings of the gas outlet conduits, and further to allow a certain length necessary for some spare material, according to the manner of charging the charging shaft. If, for instance, iron ores are to be reduced, an electrode of 2 meters' length will be completely covered by the charge and also the electrode socket will get down in course of time into the charge, as the electrode is consumed during the course of the process. If, however, the height of the normal working shaft of an electric raw iron furnace amounts, for instance, to about 1.5-2 meters, the height of the charging shaft forming the extension of the former will amount to about 1.5-3 meters or even more."

Synthetic Rubber

By Andrew H. King

When the great chemist, Bayer, completed his synthesis of indigo and placed his process on a commercial footing, the indigo planters received a rude shock. They had been content to let well enough alone. To tent the old way was the best way. They wanted no theorists about. They were practical men. The methods were old, time-tried, and unalterable. When things didn't go right they blamed it on God. Needless to mention there were many instances when something went wrong. The variation in their product kept the dyers constantly on the jump. Indigo sold at a high price, and the business amounted to something like \$25,000,000 annually.

It is no wonder that the planters felt secure. Indigo was a mysterious substance, could only be produced by natural means, and all the labor of the theorist was worse than useless. So they thought. Synthetic indigo was a man's task. It took Bayer fifteen years to determine its chemical constitution and to synthesize it. To render its production a commercial possibility twenty more years were required. The Badische Company spent millions of dollars. The first process, which started with toluene, was discarded because too little of this liquid was available. Finally, by accident, a way to convert naphthalene to phthalic acid was found, and another synthesis followed. Naphthalene is readily obtained from coal tar. It is consequently cheap, and the quantity is almost unlimited.

Synthetic indigo was soon in great favor. Its uniformity, its purity, and therefore its great strength made it much superior to the natural substance. It was cheap and increasing demand had but little effect on the price. Within a very short time natural indigo declined to almost a curiosity.

When the utilization of rubber became a business the demand for the crude gum sent the price up like a skyrocket. In 1910, which date may be taken as the beginning of modern rubber expansion, only 80,000 tons of crude rubber were produced. Of this quantity but 8000 tons were plantation grown. Seventy-two thousand tons were wild rubber, and as variable in quality as can be imagined.

Here was certainly a field for the synthetist. With the remarkable success of Bayer as an incentive, organic chemists all over the world went to work. Forgetting the great expenditure of time, energy and money that the conquest of indigo required, the world expected immediate results. When these were not forthcoming many said it could not be done. Even to-day the opinion of many rubber chemists is that synthetic rubber is only of theoretical and scientific interest.

This may all be true, but if so it is only because the men who laid the foundation of plantation rubber well knew the story of natural indigo, and availed themselves of the botanist. They met science with science. By 1915 their yearly production was 146,000 tons, as against 8000 tons in 1910. The ready demand for this rubber makes me wonder to what unknown figure this commodity would have risen if the old haphazard methods had not given way to science.

To date synthetic rubber has done remarkably well. The first step of any synthesis is to determine the structure of the material you wish to build up. Since rubber is a colloid its chemical structure is rather difficult to visualize. This has now been done with a reasonable degree of certainty. Various methods of synthesis have been developed, which while they are very expensive have merit in that they actually produce caoutchouc. There remains only the commercial production. Our friends the botanists are making this

more difficult every year. Still we have hopes. It is my claim that not sufficient time has elapsed, not enough energy been given to the proposition to yet justify its discard as unworkable. It, therefore, behooves us, as American chemists, to give thoughtful consideration to the matter. As a preparedness measure a successful commercial synthesis of rubber would be invaluable.

The Structure of Caoutchouc

By caoutchouc is here meant the pure rubber hydrocarbon, differentiating it from rubber, which contains besides caoutchouc various resins, proteins, etc., all of which have a bearing on the commercial value of rubber.

The facts having the greatest bearing on this question may be listed as follows:

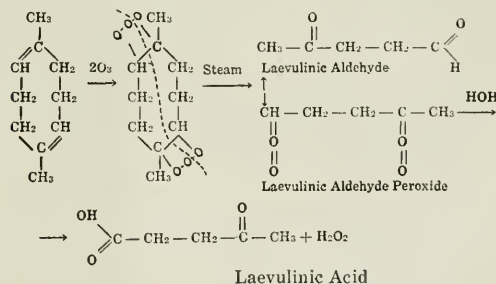
- (1) Caoutchouc has been found to be a hydrocarbon having the empirical formula $(C_8H_{16})_n$ or $(C_{10}H_{18})_n$.
- (2) It readily forms a tetrabromide, $C_{10}H_{16}Br_4$.
- (3) When combined with a maximum amount of sulfur (32 per cent) a compound $C_{10}H_{16}S_2$ is produced.
- (4) If caoutchouc is but partially saturated with bromine, i.e., only two atoms of bromine added on, but one atom of sulfur can be subsequently combined.
- (5) When treated with ozone and ozonide $C_{10}H_{16}O_6$ is produced.

From the above it appears that caoutchouc is a hydrocarbon having two double bonds for every ten carbon atoms.

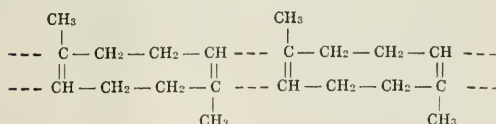
Harries¹ has attacked the problem from the standpoint of the ozonides and their hydrolysis products. He very carefully prepared the pure caoutchouc, dissolved it in chloroform, and passed ozone through the solution. In this way he obtained the ozonide, $C_{10}H_{16}O_6$.

On treatment with steam this yielded laevulinic acid, laevulinic aldehyde, and hydrogen peroxide.

The simplest explanation of the above requires the assumption that caoutchouc is 1:5 dimethylcyclooctadiene. On treatment with ozone, a diozonide is formed which splits on hydrolysis to laevulinic aldehyde and laevulinic aldehyde peroxide, which is further hydrolyzed to laevulinic acid and hydrogen peroxide.



It will be noticed that the foregoing may be applied to a ring of any size. It is generally accepted that the caoutchouc molecule is very large. Harries originally considered that it was made up of a number of $C_{10}H_{16}$ nuclei, held together, according to Thiele's theory, by the partial valences of the double bonds.



If this were true, we would expect that on destructive distillation, simple dimethylcyclooctadiene would be ob-

¹Ber. 1904, 37, 2708.

tained. This is, however, not the case, since by the most careful distillation under a vacuum the simplest substances obtained have at least 20 carbon atoms.

This and other reasons lead Pickels to suggest that instead of the eight-membered ring one of at least 32 carbon atoms would be more correct.

Harries⁹ has lately retracted his original eight-membered ring theory, and now considers that the ring contains 20 carbon atoms. He has conclusively demonstrated that hydrolysis of the ozonide yields only laevulinic acid and laevulinic aldehyde. Therefore, the structure must be that of a ring. If it were a chain the oxidation products of the two end C_2H_5 groups would certainly be present.

It is the practice of organic chemists in studying a compound first to break it down, and if possible to identify the decomposition products. This done, they attempt to synthesize it from compounds whose structures and properties are known.

On dry distillation rubber yields a number of substances, among which is isoprene. This diolefine was first isolated and named by Grenville Williams in 1860.¹⁰ Later, 1875, Gustave Bouchardat¹¹ undertook a detailed investigation of isoprene, and among other things he found that treatment with concentrated aqueous hydrochloric acid in the cold (0 deg. C.) and subsequent distillation, that a solid residue was obtained. This he found to possess "the elasticity and other properties of rubber itself." It dissolved in carbon bisulfide, and was precipitated by alcohol. On dry distillation he obtained the same products as are given by natural rubber under like treatment. This statement of his has been questioned by certain chemists on the ground that analytical methods were not highly developed in his day, and serious mistakes were possible.

Tilden in 1882¹² in a paper on "Hydrocarbons of the Formula $(C_5H_8)_n$," mentioned that isoprene was converted to rubber by the action of nitrosyl chloride. In 1892¹³ in another paper he told of the spontaneous conversion of isoprene to rubber. A bottle of isoprene prepared from turpentine many years before was found to contain instead of a clear, limpid liquid, "a dense syrup, in which were floating several large masses of a solid of a yellowish color." He found the liquid acid to litmus, and accounted for the spontaneous polymerization by the hypothesis that a small quantity of acetic or formic acid had been produced by the oxidizing action of the air, and that the change had been brought about by this substance or substances.

Wallach¹⁴ in 1885 stated that isoprene placed in a sealed tube and exposed to the action of light for a long time gave a product which on treatment with alcohol formed a tough mass resembling rubber, but becoming more or less hard on exposure to air.

The experiments of Tilden and Bouchardat were repeated by Weber,¹⁵ who obtained 211 grams of caoutchouc from 300 grams of isoprene after keeping for nine months. This work was later checked by Pickels¹⁶ and by A. Heinemann in 1907.

Late in 1909 certain samples of synthetic caoutchouc prepared by Fritz Hoffmann were sent by Duisberg to Harries for test. The latter was able by means of the hydrolysis of the ozonide to prove beyond a shadow of a doubt that the material was actually caoutchouc.

Harries¹⁰ was unable to duplicate the experiments of Bouchardat and Tilden, and he held that these men, if

they did produce rubber, were fortunate in having just the right conditions. He also calls attention to the fact that they did not prove sufficiently that they actually had caoutchouc. For, as Klages has pointed out, isoprene yields a number of substances on polymerization, many of which can be characterized as rubber-like, but which bear very little relation to rubber.

For some time past a more or less acrimonious argument has been in progress between certain English chemists, notably Perkin, Jr., and Germans, represented principally by Harries. The former hold Bouchardat and Tilden the discoverers of synthetic caoutchouc, and the latter claim that the honor belongs to Hoffmann.

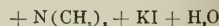
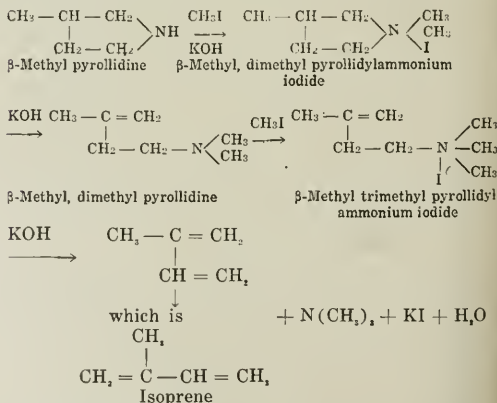
Now isoprene is a very peculiar substance, and is capable of existing in various degrees of purity. On polymerization it yields various products which differ principally in the number of $(C_5H_8)_n$ groups in the aggregate. To produce rubber from isoprene the polymerizing conditions must be well regulated, all of which Hoffmann seems to have done. Regardless of whether Bouchardat, Tilden or Wallach did have rubber or not, they said they had, and certainly a work which supplies incentive to other investigators is not valueless.

Science is international, a servant of world progress, and any attempt to classify an advance as strictly English or strictly German is not in keeping with the best interests of civilization.

We have now demonstrated that natural caoutchouc is very probably a polymerization product of isoprene. Harries was able to show that Hoffmann's synthetic caoutchouc, which was made from isoprene, yielded on hydrolysis of the ozonide the same products as natural gum, namely, laevulinic acid and laevulinic aldehyde. Thus we know that caoutchouc is made up of $(C_5H_8)_n$ groups, united in a ring. Upon the number of these groups in the ring is thought to depend the commercial value of the rubber.

Formulæ

On analysis isoprene was shown to have the empirical formula C_5H_8 . Tilden¹² as far back as 1882 considered it to be β -methylcrotonylene, $CH_2 = C(CH_3) - CH = CH_2$, but he made no experiments to bear out his theory. All the early investigators obtained their isoprene from natural sources. Bouchardat secured his from caoutchouc itself, and Tilden from turpentine. No one had produced isoprene by well defined chemical methods from a substance whose structure was known. In 1898 Euler¹⁷ produced it from β methylpyrrolidine by exhaustive methylation.



⁹J. Chem. Soc., 1915, A1253.

¹⁰Proc. Roy. Soc., 1860, 10, 516.

¹¹Compt. rend., 1879, 89, 361 and 1117.

¹²Chem. News, 46, 220.

¹³Chem. News, 65, 265.

¹⁴Annalen, 227, 295.

¹⁵J. Soc. Chem. Ind., 1894, 13, 11.

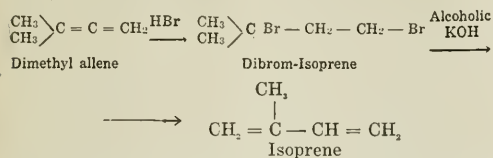
¹⁶Trans. Chem. Soc., 1910, 97, 1085.

¹⁷Chem. Ztg., 34, 315.

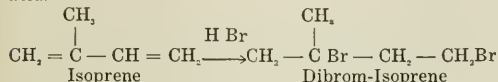
¹⁸Chem. News, 46, 220

¹⁹J. prakt. Chem., 57, 132.

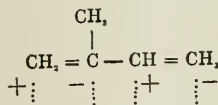
Ipatieff¹³ also synthesized isoprene. He began with dimethyl-allene, added two molecules of hydrogen bromide, and subsequently removed them.



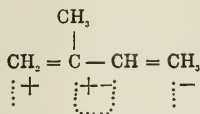
The dibromide mentioned above is identical with the one formed on treatment of isoprene with hydrobromic acid.



You will notice that isoprene contains the grouping $C=C-C=C$. This was called by Thiele a "Conjugated System." It would be expected that such a compound when treated with bromine would add on four atoms, one on each carbon, thus $CH_2Br-C(CH_3)Br-CHBr-CH_2Br$. This is, however, not the case, for only two atoms of bromine are added, and they go to the end carbons, forming a double bond in the center: $CH_2Br-C(CH_3)=CH-CH_2Br$. Thiele's explanation of such phenomena is based upon his theory of "Partial Valences." It is imagined that two atoms when held together by a double bond, do not have the whole of their affinity used up, and that each possesses a slight excess of valency, to which the great additive power of unsaturated compound is attributed. Now, if we indicate the partial valences by dotted lines, and consider the carbon atoms of the chain as alternately charged with positive and negative forces, we may write isoprene

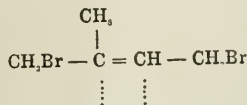


The partial valences of the two interior atoms neutralize one another so that we have

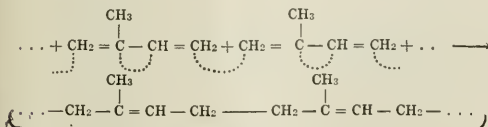


From this it is clear that when addition takes place, it can only occur at the end carbons, and a new double bond appears at the center.

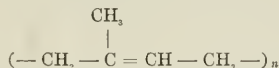
This becomes intensely interesting and instructive.



when we try to visualize the manner in which isoprene is polymerized to caoutchouc. According to this theory,



We now know that a relatively large number of isoprene groups linked together to form caoutchouc, so that we may write its formula:



This n we know to be something less than 40.

The Synthesis of Caoutchouc

It is now believed that any substance containing a conjugated system, $C = C - C = C$ is capable of polymerization to a rubber-like substance. The hydrocarbons of most interest, and with which this is possible, are the following:

(1) Butadiene $\text{CH}_2 = \text{CH} - \text{CH} = \text{CH}_2$, known also as Erythrene, Divinyl, and Crotonylene. This substance when polymerized gives a caoutchouc which was called by Harries, Nor-caoutchouc, since a "Nor" substance is the synthetic methyl-free, mother substance of a series of bodies.

(2) Isoprene, α -methyl-butadiene, $\text{CH}_2 = \text{C}(\text{CH}_3) - \text{CH} = \text{CH}_2$, is the parent substance of natural rubber.

(3) Piperlyene β -methyl-butadiene, $\text{CH}(\text{CH}_3) = \text{CH} - \text{CH} = \text{CH}_2$.

(4) Dipropylene or 2, 3, dimethyl-butadiene.



(5) 1, 4, tetra-methyl-butadiene.



One of the most serious difficulties in the way of a satisfactory synthetic caoutchouc is that of polymerization. As was previously related, isoprene and its homologues tend to polymerize to substances of higher molecular weight. This action does not by any means always produce rubber. It is very important that the right conditions as well as the correct catalyst be determined so as to give a high value for " n ." If by any chance the right conditions are not maintained, or if some impurity is introduced, which poisons the catalyst, the polymerization product will be a dirty, sticky, resinous mess of no value whatsoever.

According to Harries,¹⁴ natural caoutchouc exists in three type forms:

- (1) Ordinary solid crude caoutchouc.
- (2) Insoluble form.
- (3) Oily.

All are mutually transformable. (3) goes to (1) slowly but spontaneously. (1) goes to (3) on warming in solution. The change from (1) to (2) or (2) to (1) is also spontaneous. (3) may be converted to (2) by acetic acid.

Artificial cautchouc behaves in a similar manner. The purer it is the more readily does it pass into the insoluble form. The best yield is obtained from pure specimens of isoprene, irrespective of the method of preparation. The artificial cautchouc must be kept in an atmosphere of carbon dioxide and protected from light, or oxidation is likely.

A brief review of some of the most important methods of bringing about polymerization is given below:

Auto-polymerization:

Elberfelder Farb., British Pat. 15,254, 1910, describes the following methods:

(1) Butadiene dissolved in benzole is heated ten hours at 150 deg. C. for a number of days.

(2) Butadiene condensed at a low temperature by means of ether and carbon dioxide is kept in an autoclave at 90 to 100 deg. C. for four days. In both cases the solvents, unreacted upon material and by-products, are distilled off in vacuo or by steam, and a rubber like mass remains.

Piperylene may be polymerized on long heating, fourteen days at 105 to 110 deg. C.

Conditions vary slightly for the various hydrocarbons, but in brief the process consists of heating them for a long time at a moderate temperature under pressure.

Various ozonides and peroxides have been added to catalyze the polymerization. The product so obtained is not overly valuable, as will be shown later on.

Acetic Acid:

Harries¹² directs that isoprene be heated with an equal volume of glacial acetic acid under pressure on a water bath during eight days. The yield varies widely, but is little affected by using different quantities of acetic acid, or by changes in the temperature. When only a few drops of acid are employed, it is necessary to distill the product under ordinary pressure, to remove the isoprene and its dimolecular polymerization product, and finally to distill at 105 deg. C. to remove any oily material. The residue is transparent, almost colorless, and closely resembles natural caoutchouc. When freshly prepared it is readily soluble in organic solvents, but loses this property on standing.

Caustic Soda:

French Pat. 417,170, 1910. Badische An. & Sod. Fab. Isoprene with the addition of 10 per cent of its weight of concentrated alcoholic soda is heated to 110 deg. C. under pressure for a sufficiently long time. After distilling off unconverted isoprene, the rubber is either dissolved in benzole and precipitated by alcohol, or is kneaded into a compact mass, from which the caustic is removed in the usual manner by washing.

Another method which finds application with 2, 3, Dimethylbutadiene, is to heat with 14 per cent caustic soda solution for 80 hours at 100 deg. C., purifying as above described.

Heating with Indifferent Material:

The Badische Company has found 2, 3, Dimethylbutadiene, that heating with an indifferent agent, as, for example, water, sodium chloride solution, alcohol, etc., that a better yield was obtained. Hydroxides of the alkaline earth metals and alkaline reacting salts are also beneficial.

Anaerobic Bacilli:

The possibility of the use of enzymes has not passed unrecognized. Gottschalk in 1907 proposed to utilize the action of bacteria on hydrocarbons.

British Pat. 15,299, 1909, covers the treatment of isoprene or its homologues with anaerobic bacilli obtained from natural rubber or latex.

By the Use of Sodium:

The discovery of this reagent was made almost simultaneously in England by Matthews,¹³ and in Germany by Harries.¹⁴

The method described by Harries is as follows:

Pure isoprene and 0.02 to 5 parts of sodium wire are heated to 60 deg. C. for 50 hours, and then purified by the usual methods. The product when freshly prepared is easily soluble, and may be vulcanized quite readily. The yield is almost quantitative. The low temperature used is a decided advantage.

For other hydrocarbons the temperature and time of heating are varied somewhat, but the basic principal remains the same.

It is sometimes an advantage to prepare sodium caoutchouc in the presence of carbon dioxide.¹⁵ The product so obtained is insoluble in butadiene and its homologues. It is dark in color, and may be converted to a white compound by water or alcohol, and may be

used for polymerizing further quantities of the dienes.

Sodium butadiene caoutchouc by the Matthews process may be improved by the use of sulfur dioxide.¹⁶ Liquid sulfur dioxide is added to a cooled benzene solution of the soluble part of the caoutchouc and the mixture warmed in a sealed vessel at 40 deg. C. After some time the vessel is opened, when the solution will be found to be very viscous and in some cases set to a jelly. A portion of the caoutchouc may even be precipitated, according to the nature of the original rubber, the concentration of the solution, and the quantity of sulfur dioxide added. On removal of the sulfur dioxide the product will be found to be elastic and to resemble natural caoutchouc. In this condition it may be compounded.

In comparing various synthetic caoutchoucs, Harries¹⁷ found the bromides and nitrosites unsuitable, and concluded that the best method was to measure the velocity of decomposition of the diozonides and dioxozonides with steam, and quantitatively determine the reaction products. The diozonide $2O_3$ is the first product of ozonization, the dioxozonide $2O_4$ is obtained by prolonged action of concentrated, unwashed ozone.

A comparison such as the foregoing is certainly very valuable to the organic investigator, but of little use to the rubber chemist. To him the most important points concerning a new variety of rubber are as follows:

- (1) Can it be vulcanized readily?
- (2) What are the physical properties, ie., its tensile strength, elasticity, set, etc.?
- (3) Can it be compounded?
- (4) What are the aging properties?

I have purposely omitted a prime essential—cost. It is of greatest importance to know what value this new rubber will give. A synthetic rubber to be a commercial possibility must give dollar for dollar an equal or greater value than the natural rubber, which could be sold if necessary at 25 cents per pound.

The method of polymerization has quite an effect on the properties of the product. Hinrichsen¹⁸ has prepared caoutchouc from butadiene, isoprene and dimethylbutadiene. The chart below shows the variation in properties.

- A—indicates auto-polymerization by heating.
 B—The same, but in presence of ozonides or peroxides as catalysts.
 C—polymerization by means of sodium in the presence of carbon dioxide.
 D—polymerization by sodium alone.

¹³Brit. Pat. 2,070, 1914, Matthews & Strange.

¹⁴Ann., 395, 211-64.

¹⁵Zeit. des Ver. Deut. Ing., 1915.

A—Indicates auto-polymerization by heating.

B—The same, but in presence of ozonides or peroxides as catalysts.

C—Polymerization by means of sodium in the presence of carbon dioxide.

D—Polymerization by sodium alone.

Manner of Polymerizing	Butadiene	Isoprene	Dimethyl-Butadiene
A.....	Elastic Easily soluble Capable of vulcanization	Elastic Easily soluble Can be vulcanized	Easily soluble Non-elastic Can be vulcanized to hard rubber only
B.....	Insoluble Very elastic Strongly inflatable Cannot be vulcanized	Soluble only after calcining Elastic Capable of vulcanization	Soluble only after calcining Inflatable Non-elastic Easily oxidized Vulcanized with difficulty
C...	Insoluble Moderately elastic Non-inflatable Cannot be vulcanized	Insoluble Elastic Non-inflatable Can be vulcanized	Insoluble Non-inflatable Non-elastic Easily oxidized Vulcanized only with difficulty
D	Elastic Easily soluble Capable of vulcanization	Easily soluble Non-elastic Vulcanized only with difficulty	Soluble and insoluble modifications Inelastic Incapable of vulcanization

¹²Ann., 383, 157-227.

¹³Brit. Pat. 24,790, 1910.

¹⁴Ann., 1911, 383, 157.

¹⁵Brit. Pat., 26,550, 1912.

The sodium caoutchouc from dimethyl-butadiene is of scientific interest because of its resemblance to gutta percha. Piperylene rubber is probably an isomeride of natural rubber. The nitrosite, bromide and ozonide decomposition velocity differ decidedly from those of normal caoutchouc.

The foregoing gives a rather brief summary of the various methods of polymerization. We now come to the preparation of these hydrocarbons. This subject is so broad that a full review is entirely beyond the scope of this paper. A large number of investigators are at work, both in this country and abroad, and it would be almost an impossibility to bring the matter up to date.

Because of the large number of methods an attempt to generalize has been made. Only the more important of these general methods will be touched.

Preparation of Butadiene and Its Homologues

I.—BY THE CRACKING OF CYCLIC AND STRAIGHT CHAIN HYDROCARBONS

Turpentine.—It has long been known that isoprene may be obtained from turpentine. The hydrocarbon used by Tilden in his experiments was obtained from this source. Harries²² has described his isoprene lamp.

It has been shown²³ that the isoprene from commercial turpentine is due to the pinene fraction, but Schörger and Sayre²⁴ are of the opinion that the heating first produces dipentene (limonene), which on decomposition yields isoprene. They further propose that a method whereby pinene may be converted to limonene would be of considerable value, since pinene yields only about 8 per cent isoprene while approximately 50 per cent may be obtained from dipentene.

A patent, U. S. 1,185,654, June 6, 1916, to E. Gottschalk, describes the cracking of pinene, which is brought about by passing the vapor through a glass, porcelain or sherardized metal tube, heated to 300 to 350 deg., producing isoprene and other hydrocarbons, which are quickly cooled, and then subjected to steam distillation.

Another patent, by A. Heinemann, U. S. 1,095,395, deals with the cracking of the vapor of turpentine, which is passed through finely divided copper in an iron tube, or through a helical, spiral, or zigzag copper tube, heated to 480 deg. A yield of 25 per cent isoprene is claimed.

In view of the above it seems quite probable that a means may be found for preparing pinene, and from it isoprene as a by-product, from the great pine forests of the West and South.

Petroleum.—It has been proposed to utilize the low-boiling point members of unsaturated petroleum, such as California oil, in the preparation of isoprene, etc. In view of the success Rittmann, Egloff and others have had in cracking petroleum to benzole and toluene, it seems to me that the production of butadiene and its homologues by somewhat the same methods would be possible.

In their cracking processes a certain amount of gas is always produced, which consists in large part of olefines. It has occurred to me that the condensation of this gas might show us a source of isoprene, thereby making it so valuable that there would be no necessity for burning it in the crackers.

In German patent 264,245, 1911, to Ges. Für Teerverwertung, a method is given for the conversion of crude butadiene, found in the lowest boiling fractions from the distillation products of coal and the crude products resulting from the distillation of mineral oils, to a form

suitable for polymerization. After the carbon bisulfide is removed, the cyclopentadiene is thermolyzed into a higher boiling polymer, the hydrocarbons of the acetylene series are removed by aid of their sodium compounds, and the butadiene is fractionated to the desired degree of purity.

Bayer & Company²⁵ have a method for the production of butadiene by breaking down petroleum fractions or residues with the aid of hot-contact substances, which are placed in the liquid petroleum.

Fats.—German patents 267,079, 267,080, 1912, to Gerlach and Koetschau, covers the production of butadiene and other unsaturated compounds by the cracking of oleic acid, its isomers and homologues, or the oil fats and waxes derived from the acids of the oleic series, or which contain such compounds, also wool fat or other materials containing cholesterol.

Condensation

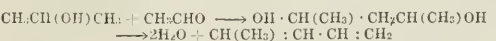
Acetylene.—The possibilities of the condensation of this hydrocarbon with olefines has always proved a very attractive problem to the young chemist. For example, Heinemann²⁶ proposed the preparation of isoprene by heating a mixture of acetylene, ethylene and methyl chloride.

$C_2H_2 + C_2H_4 + CH_3Cl \rightleftharpoons CH_2 : C(CH_3) \cdot CH : CH_2 + HCl$
Unfortunately, this rather beautiful equation is unworkable.

Acetaldehyde and Alcohols.—The researches of Ostromuisslenskii along this line are of considerable interest. He has been able²⁷ to produce butadiene by the condensation of acetaldehyde and paraldehyde with alcohol in the presence of various catalytic agents, such as red phosphorus, glacial phosphoric acid, sulfanilic acid, barium chloride, and especially alumina. Best results were obtained from the latter substance at 360 to 460 deg. C. The mixed vapors are quickly heated to reaction temperature, and the products quickly removed and cooled. A yield of 16 to 18 per cent of pure butadiene is claimed.

Ostromuisslenskii mentions that there are four intermediate compounds formed: α hydroxyethyl ether, β , γ , dihydroxy butane, δ hydroxy Δ , β butylene, and methyl allene.

Applying this method to the production of piperylene, he condenses isopropyl alcohol with acetaldehyde in the presence of alumina at about 400 deg. C.



No trace of isoprene is to be found, and the method is said to be the cheapest and simplest of any yet put forth. It is interesting to note that Ostromuisslenskii is able to produce his acetaldehyde directly from alcohol,²⁸ by passing the vapor, mixed with air, through spirals of copper and silver gauze, producing acetaldehyde mixed with paraldehyde.

It will be remembered that when the Czar made Russia dry territory shortly after the great war started in 1914 that his Minister of Finance, when faced with a \$500,000,000 deficit because of the shutting off of vodka revenue, offered a number of cash prizes for a commercial process whereby the alcohol from his distilleries might be utilized.

From the Jan. 5, 1916, issue of the *India Rubber Journal* we learned that the Minister of Finance has proposed the expenditure of £30,000 to erect a factory

²²German Pat., 283,162 and 251,217.

²³Brit. Pat., 21,772, 1907.

²⁴J. Russ. Phys. Chem. Soc., 47, 1509—28, 1494-1506, 1507-09, 1915. Chem. Abst., 10, 2178-9 (1916).

²⁵Agr. Gaz. Petrograd, 25, 701 6; 26, 727-8; Chem. Abst., 10, 3000, 1916.

²⁶J. Chem. Soc., 1911, i, 798.

²⁷Herty & Graham, J. Ind. Eng. Chem., 6, 803-4.

²⁸J. Ind. Eng. Chem., 7, 924-6.

for the preparation of synthetic rubber from alcohol by a process invented by Ostromuisslenskii.

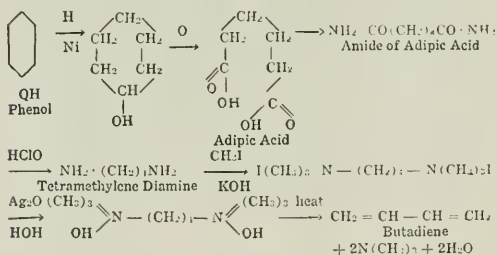
The process here spoken of is in all probability the one described above. In view of the ever-increasing "dry" sentiment in this country, it seems that this matter would bear investigation and research on the part of the great American distilleries, which may yet have to turn to the manufacture of industrial alcohol.

This Russian chemist has lately published some rather remarkable work on the vulcanization of rubber, the preparation of synthetic caoutchouc, and the nature of the rubber hydrocarbon. With it all, he has come in for some very severe and, to my mind, undeserved criticism. The fact that he has been able to convince the Minister of Finance of an almost bankrupt nation, a nation at war, that his processes are worth risking £30,000 on a tryout, is certainly a point in his favor. It may be that like other investigators he finds it necessary to refrain from publishing some of the important details of his work, so as to protect himself from infringement.

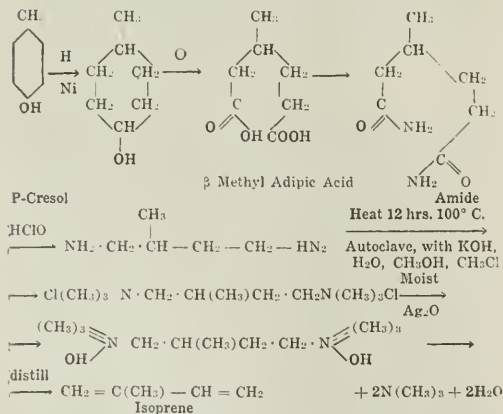
Opening the Benzene Ring

From Coal Tar.—A process for the large scale production of isoprene and butadiene has been worked out by Hoffmann and patented by Bayer & Company.²⁰ The starting point is either phenol or para-cresol, depending upon whether butadiene or isoprene is desired. Both phenol and p-cresol may be obtained from coal tar, as well as from benzole, by known methods.

SYNTHESIS I



SYNTHESIS II



Synthesis I.—The phenol is first reduced by hydrogen in the presence of nickel (Sabateir and Sendern's method), oxidized to adipic acid, thus splitting the ring. This is next converted to the amide, which on treatment

with hypochlorous acid is converted to tetramethylenediamine, which in its turn is treated with caustic potash and methyl iodide. The product is treated with moist silver oxide, converting it to a base, which on heating yields butadiene, water, and trimethyl amine.

Synthesis II.—For isoprene, para-cresol is used, and the only difference in the process is that the β methyl-tetramethylenediamine is heated with methyl chloride, methyl alcohol, water, and caustic potash instead of methyl iodide and potash as above.

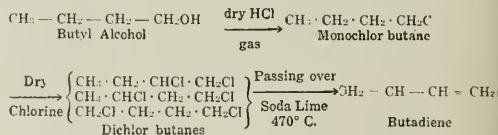
These are truly remarkable syntheses, and that they are workable on a large scale is certainly a credit to the German chemists. It is understood that these two processes supply most of the synthetic rubber now manufactured in Germany.

Fermentation

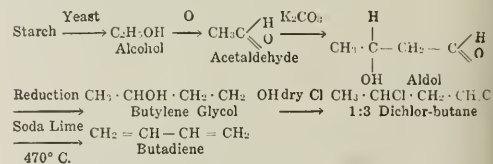
From Starch.—As is well known, small amounts of fusel oil are produced in ordinary alcoholic fermentation. It is a by-product, and while extremely valuable, it must be separated from liquors containing it because of physiological effects. It occurred to Fernbach that if the bacteria causing the formation of the higher alcohol could be isolated and allowed to act alone on starch that a cheap source of butyl alcohol would be provided.

With this in view, Fernbach and Strange²¹ were able to devise processes for the production of acetone and butyl alcohol. The fermentation of starch by the *butylic bacillus* of Fitz is accelerated by the products resulting from the action of *Tyrophix tenuis bacillus* on the nitrogenous matter present in yeast. It is claimed that a yield of 42 per cent fusel oil is obtained.

The butyl alcohol is converted by dry hydrochloric acid gas to chloride, which is then treated with chlorine gas under carefully regulated conditions, producing three dichlorides. On passing the dichlorides over soda lime at 470 deg. C. butadiene is obtained.



By the Acetaldehyde route.—This method, devised by Perkin, Jr., consists in converting starch by yeast to alcohol, then by oxidation to acetaldehyde, to aldol by potassium carbonate, which is next reduced to butylene glycol. The glycol is treated with dry chlorine, converting it to 1:3 dichlorbutane, which on passing over soda lime yields butadiene.

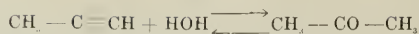


In view of the late work on dehydration of secondary alcohols by Kyriakides, Spence, Ostromuisslenskii, and others, this process looks very old-fashioned, and needlessly long. It has probably been abandoned.

Both Perkins' process and that of Fernbach and Strange, were worked by the Synthetic Products Company, a London corporation. Since this concern has lately come to grief, it might be of interest to trace some of its difficulties.

²⁰Eng. Pat., 24,298, 1909.

²¹English Patent, 15,203, 15,204, 16,925 (1911).



Methyl Acetylene

Acetone

To the best of my knowledge these reactions are mainly of interest from a theoretical standpoint, and have no practical application. It seems, however, that there is a slight tendency for them to take place. All reactions are susceptible to the influence of catalysts. If acetylene and water tend to produce acetaldehyde, the means must exist whereby the reaction may be forced. A thorough search for the proper catalyst would doubtless bring this about.

From a standpoint of industrial preparedness, a cheap synthetic rubber would be our salvation. The average man little considers the absolute need of rubber, both for peace and for war. Should the seas ever be closed to us, under present conditions, the suffering would be colossal.

As I have mentioned in a previous paper, we have only three ways to absolutely protect ourselves:

(1) Cultivate and harvest guayule by scientific methods.

(2) Develop something from milkweed, or related plants.

(3) Work up a good synthetic rubber.

There are now in this country several investigators of real worth at work on synthetic caoutchouc. They deserve every consideration and every possible help.

Should this problem ever be solved, I venture to predict that the starting point will be either a derivative of petroleum or a product of acetylene.

Should it never be solved, the possibility of its solution will serve as a spur to drive the planters to greater economy, and better methods of production. Consequently the public will benefit either way, since the price of rubber must constantly decline.

This country of ours must be made economically independent. In this and in two previous papers (Guayule and Industrial Preparedness, The Rubber Situation), I have tried to convey an idea as to just how badly we might be off for rubber. I have also tried to indicate certain means by which the present condition may be alleviated. If I have succeeded in arousing your interest, then I am content.

Alcohol Plants Offered to Government.—Along with many chemical and industrial plants which have been offered to the Government, the Distillers Securities Company has placed its alcohol plants at the Government's disposal. The company controls at least 100 separate establishments for distilling and handling ethyl alcohol.

Institute of Metals Meeting.—The annual meeting of the Institute of Metals was held on March 21 and 22 in London. The president, Sir George Beilby, presided. A special feature of the meeting was a general discussion on metal melting. Abstracts of several of the papers presented on this subject will be found under synopsis of recent literature in this issue. A report was presented on the Corrosion Research Committee, which had been reconstituted during the past year. The laboratory of the committee was transferred to the Royal School of Mines. Work has been commenced on a scheme including a detailed study of a number of factors which have been suggested as determining the initiation of corrosion, and an attempt to estimate their relative importance in the case of a pure metal. A start has been made on the study of certain physical factors, and on the influence of small quantities of "impurities," such as oxide. It is believed that the knowledge so obtained will help materially in the interpretation of results already obtained in the investigation of brass and other alloys.

Effusion Method of Determining Gas Density*

By Junius David Edwards

The effusion method of determining gas density has been in common use for over half a century, in practically the same form as originally developed by Bunsen¹ and Schilling². This method is based upon the fact that the times required for the escape of equal volumes of two gases under the same pressure through the same small orifice are approximately proportional to the square roots of the densities of the gases. Frequent lack of agreement between the different users of this method has given rise to many controversies regarding the accuracy of the method. Because of this unsatisfactory state of affairs the Bureau of Standards, at the request of certain gas companies, undertook an investigation in order to discover the sources of error in the method and to develop the apparatus and technique necessary to secure the best results.

Preliminary Tests

As a part of the investigation, a preliminary series of tests was made at the Bureau with the co-operation of Messrs. S. S. Wyer, T. H. Kerr, P. M. Biddison, H. T. Ashton, and T. R. Weymouth. These tests were designed to determine the accuracy of the method as used under field conditions by experienced observers.

The majority of the tests were made with two pieces of apparatus, one of which is illustrated in Fig. 1. The second apparatus was practically the same except that it had a three-way cock with a side outlet instead of the simple two-way cock shown in Fig. 1. The pressure at the start of each test was approximately 8 in. of water; that at the finish is given in the table.

The specific gravity of the gases used was carefully determined by the method of direct weighing described in a succeeding section. The results are thus referred to a standard method of the required accuracy. From inspection of the results it is seen that results in error by as much as 13 per cent were obtained with one of the orifices tested.

No consistent improvement in accuracy was obtain-

*Published by permission of the Director, Bureau of Standards. The investigation, of which this paper is a condensed report, will be published in full as a Technologic Paper of this Bureau.

¹Bunsen, *Gasometrische Methoden* 1857, p. 128.

²Schilling, *Handb. d. Steinkohlengasbeleuchtung*, 3d edition, p. 106.

TABLE I.—PRELIMINARY SERIES OF TESTS WITH EFFUSION APPARATUS
(A) Tests made with natural gas of specific gravity 0.732 (saturated gas with water vapor referred to saturated air at 30 deg. C., 760 mm. pressure.)

Test	Orifice	Effusion Pressure at Finish (Inches of Water)	Apparent Specific Gravity	Error (per cent)
1	13	2.0	.695	- 7.6
2	13	0.5	.696	- 7.5
3	13	2.0	.704	- 6.4
4	13	0.5	.684	- 9.0
5	13	0.5	.671	-10.8
6	13	2.0	.648	-13.8
7	13	0.5	.687	- 8.6
8	4	2.0	.764	+ 1.6
9	4	2.0	.764	+ 1.6
10	4	2.0	.764	+ 1.6
11	4	2.0	.768	+ 2.1
12	4	2.0	.764	+ 1.6
13	4	2.0	.764	+ 1.6
14	4	0.5	.756	+ 0.6
15	1	2.0	.762	+ 1.3
16	1	0.5	.718	- 0.6
17	5	2.0	.739	- 1.7
18	11	0.5	.712	- 5.3
19	11	2.0	.721	- 4.1
20	11	2.0	.728	- 3.2
21	12	2.0	.754	+ 0.3

(B) Tests made with natural gas of specific gravity 0.650 (saturated gas referred to saturated air at 20 deg. C., 760 mm. pressure).

22	13	2.0	.627	- 3.5
23	4	2.0	.657	+ 1.1
24	11	2.0	.634	- 2.5
25	12	2.0	.644	- 0.9
26	50	2.0	.629	- 3.2

able by several variations in the method of operation nor was any satisfactory explanation of the results forthcoming from a consideration of the theory of the effusion process as understood at that time. For further progress a better understanding of the theory was therefore necessary, and this phase of the problem was next investigated.

Theory of the Effusion Method

The fact that the speeds of effusion of different gases are approximately inversely proportional to the square roots of their densities was empirically discovered by Graham³ and others, and its use as a means of determining the specific gravity of a gas was suggested by him. On the basis of the kinetic theory of gases, the speed with which a gas will pass through a small opening (speed of effusion) must be proportional to the average speed of the molecules. Since the molecular speed of a gas is inversely proportional to the square root of its density, the rate of effusion is inversely proportional to the same quantity. The times t required for the effusion of equal volumes of different gases under equal pressures are therefore directly proportional to the square roots of the densities of the gases.

$$\text{Specific gravity} = \frac{d(\text{gas})}{d(\text{air})} = \frac{t^2(\text{gas})}{t^2(\text{air})}$$

This theory assumes that the process is isothermal and that there is no loss of energy through friction in the orifice. At atmospheric pressure it is known that these conditions are not satisfied; the phenomenon is one of stream line flow and is affected by a number of factors of which the kinetic theory takes no account.

The effusion method is not concerned with the absolute rate of effusion of any gas, but only with the ratio of the rate of effusion of the gas and of air. For this reason it may be expected that deviations from the law will result from differences in certain physical properties of the gases, such as the ratio of the specific heats, the viscosity, the thermal conductivity, etc. However, because of the number of factors involved, the complete development of the theory has proven to be very difficult and a satisfactory correlation of all the variables has not yet been accomplished. It is desired at this time to present only the empirical relations between variables as shown directly by the experiments and leave to a later paper the theoretical discussion of these. The development of the theory has been done in collaboration with Dr. Edgar Buckingham of the Bureau.

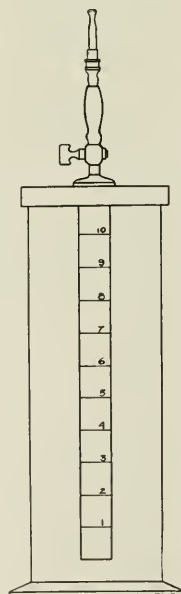


FIG. 1—EFFUSION APPARATUS USED IN PRELIMINARY TESTS

Experimental Apparatus and Methods

Gases Used.—Three samples of natural gas and one each of hydrogen, carbon dioxide, air, and argon (containing 33 per cent argon) were used. The gases were

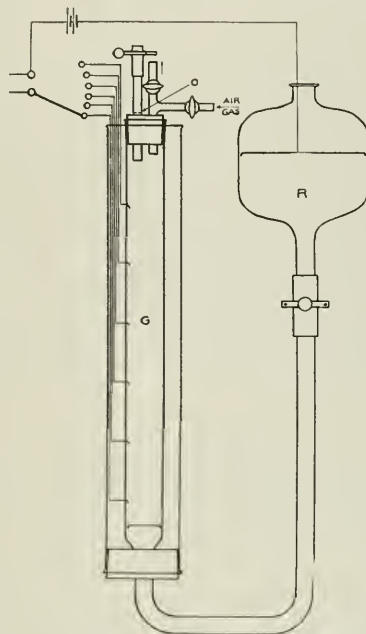


FIG. 2—EFFUSION APPARATUS FOR STUDYING EXPERIMENTAL CONDITIONS

delivered from steel cylinders at the proper working pressure by means of pressure regulators.

Standard of Comparison.—The density of the gas contained in each cylinder was determined by direct weighing of an accurately determined volume of gas, at a definite pressure and temperature in a glass globe. The specific gravity of the gas was calculated from this weight and the weight of an equal volume of air determined in the same way.

Effusion Apparatus.—The apparatus used in the study of the variables of the effusion process is shown in Fig. 2. This apparatus was used especially for studying the effect of pressure upon the rate of effusion. It consists of a cylindrical chamber G , containing the gas, connected by a glass tube to the mercury reservoir R . The rubber stopper closing the gas chamber carried the orifice tube and the tube for introducing the gas and air, as shown. The gas could be introduced at any desired pressure.

An automatic electrical method of timing was used. A series of platinum contacts properly insulated on the outside were sealed into the walls of the gas chamber at approximately equal intervals. When the gas was effusing, the ascending column of mercury, closing the circuit at each terminal, recorded the time of contact on a chronograph operated by the master clock of the Bureau. The time of effusion for different intervals could, by this means, be determined to 0.05 second. Observational error in the timing was thus practically eliminated.

Orifices.—Each orifice was made by piercing a small hole in a metal plate, and sealing it into a glass tube. All the orifice plates used for this investigation were of

³Phil. Mag. (3) 2, p. 175: 1833.

platinum-iridium (15 per cent iridium); this alloy makes a very stiff and serviceable plate. The orifice plate, usually 5 to 6 mm. in diameter was pierced by a needle of approximate size, using a soft metal backing. The hole was then cleaned out and enlarged as desired by proper reaming with a needle. Any burr could be removed and the plate ground down to the desired thickness by careful grinding on fine emery paper. When finished, the thickness of the plate was determined by means of micrometer calipers and the diameter of the orifice was determined with the aid of a microscope. The microscope was also used in determining the condition of the orifice during the finishing process. The plate, when completed, was sealed into the end of a glass tube and another glass tube sealed on next to it. The finished orifice then consisted of a platinum-iridium plate sealed into the center of a glass tube.

The tubes were numbered by etching so that either face of the orifice plate could be identified at any time. The letters *A* and *B* are used to distinguish the two sides of the orifice. For example, when "orifice 10A" is used it means that orifice number 10 was used in such a position that the gas passed through the orifice from side *A* to side *B*.

Effect of Experimental Conditions Upon the Apparent Specific Gravity

The effect of variation of effusion pressure on the relative rates of effusion of air and hydrogen, argon, methane, and carbon dioxide through the same orifice, (No. 28B) are shown by the curves in Fig. 3. The values of *R*, plotted as ordinates, are the ratios of the

apparent specific gravities ($S = \frac{t_g^2}{t_a^2}$) to the true specific

gravity of the gas. The values of *r* plotted as abscissas are the ratios of the back pressure (atmospheric) to the effusion pressures. For example, if the atmospheric pressure is 760 mm. of mercury and the average effusion pressure is 190 mm. in excess of the pressure of the

atmosphere, then $r = \frac{760}{760 + 190} = 0.80$.

The values of *r* nearest 1.0 represent the lowest effusion pressures.

A number of facts are at once evident from an examination of these curves. They illustrate in a striking manner the very different behavior of different gases. Different orifices give curves which have the same characteristic form for a given gas, although the values of *R* vary considerably. The apparent specific gravity is distinctly a function of the pressure. The combination of factors, which produces such a low result in the case of carbon dioxide, produces just the opposite effect in the case of hydrogen. While there may be a pressure at which the effusion method gives the correct specific gravity for a given gas with a given orifice, there is evidently no effusion pressure at which any one orifice will give the correct specific gravity for every gas.

Except for the correction due to the fact that the effusion is practically adiabatic, the major part of the deviations noted can be explained by differences in the viscosities of the gas and the air. If it were possible to calculate the correction in any given case, the fact that it would require a determination of the ratio of the specific heats, the viscosity, and possibly other physical constants of the gas, would prevent any commercial use of such a method.

The Effusion Pressure.—The effect of variations in the effusion pressure upon the relative rates of effusion of different gases was pointed out in connection with Fig. 3. It may be concluded from these curves and a consideration of a large mass of other data that a very

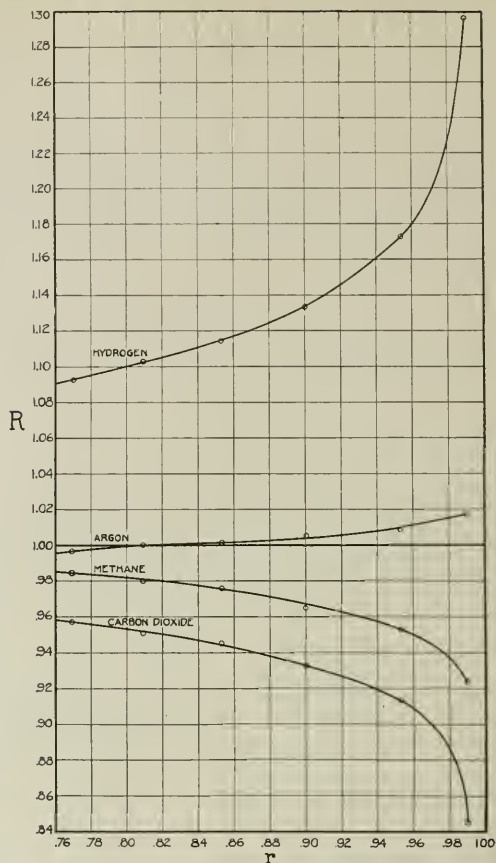


FIG. 3.—CURVES SHOWING THE APPARENT SPECIFIC GRAVITY OF DIFFERENT GASES AS DETERMINED WITH ORIFICE NO. 28B AT DIFFERENT EFFUSION PRESSURES

low effusion pressure should, in general, be avoided. However, the converse is not generally true, namely, that the higher the effusion pressure the more nearly correct the apparent specific gravity will be.

The Confining Medium.—The use of water as a confining liquid is attended with a number of disadvantages. The gas, being in contact with water, must be measured saturated with water vapor at the temperature of the test; and the specific gravity value obtained is then the ratio of the weights of saturated gas and saturated air. The specific gravity of a gas is usually defined as the ratio of the weight of a given volume of gas to the weight of an equal volume of air, dry, free from carbon dioxide, and measured at the same temperature and pressure. This definition may be extended to include the value obtained with the effusion apparatus using water by stating that both gas and air shall be saturated with water vapor. It should be clearly borne in mind, however, that the specific gravity of dry gas referred to dry air may be very different from the specific gravity of saturated gas referred to saturated air. The latter value is, of course, not constant but is different at different temperatures and pressures. For example, if the specific gravity of a gas is 0.500, then the specific gravity of the saturated gas referred to satu-

rated air at 20 deg. C. and 760 mm. pressure will be 0.507.

The expansion of the gas in passing through the orifice results in a considerable lowering of its temperature with the consequent condensation of water vapor. This water frequently adheres to the rim of the orifice, materially changing its diameter and giving erroneous results for the apparent specific gravity since the area of the orifice may vary from one test to the next as water is condensed or evaporated from its walls. When this occurs the effusion time may vary quite erratically. When this difficulty was experienced, passing dry gas through the orifice previous to each test made it possible to secure consistent readings, thus confirming the belief that the condensation of water vapor was the cause of the erratic results.

Mercury is the ideal confining medium from the standpoint of precision since its vapor pressure is negligible and gases are insoluble in it. Its high density may, however, introduce difficulties when it is desired to secure a low effusion pressure. Mercury was used in most of the experiments reported.

The Orifice.—The character of the orifice employed is of prime importance. The shape of the orifice has an important effect upon the relative rates of effusion. The same orifice, used under exactly the same conditions except that the direction of flow through it is changed, may give a different apparent specific gravity, thus showing the effect of changing the form of the orifice (as viewed from the side of the effusing gas) without changing its diameter. In Fig. 4, for example, the curves for orifices 25A and 25B show that reversing the orifice in the apparatus makes a difference of 1 to 2 per cent in the apparent specific gravity.

The experimental results show that, almost without exception with the orifices examined, the position showing the lower air effusion time gives for the natural gas the lower value for the apparent specific gravity. The same factors would have the opposite effect in the case of hydrogen, giving a higher apparent specific gravity. Some idea of the character of an orifice may be obtained by comparing the air effusion times when it is used in both positions. If there is considerable difference, the position giving the longer time is the preferable one to use.

The variation in the apparent specific gravity of methane when determined with six different orifices is shown in Fig. 4. It is to be noted that in form the

curves are quite similar. The characteristics of these orifices were as follows:

Orifice 25.....	0.12 mm. diameter.....	0.09 mm. thickness of plate
Orifice 22.....	0.09 mm. diameter.....	0.02 mm. thickness of plate
Orifice 23.....	0.05 mm. diameter.....	0.05 mm. thickness of plate
Orifice 23.....	0.06 mm. diameter.....	0.04 mm. thickness of plate
Orifice 28.....	0.07 mm. diameter.....	0.10 mm. thickness of plate

Similar series of curves have been obtained for the other gases used. The results are in each case a set of nearly parallel curves with the same relative arrangement with respect to the orifices. With curves shaped like those for carbon dioxide or methane in Fig. 3 the larger orifice gives the higher result; but with curves like those for hydrogen and argon the larger orifice gives the lower values.

These with other results show that, in general, an increase in the thickness of the plate or decrease in the diameter of the orifice results in a lower apparent specific gravity for the methane. In the case of hydrogen the converse is true, the same changes producing an increase in the apparent specific gravity.

A more definite idea of the effect of size of orifice can be obtained from a consideration of the data in Table 3 where results for methane with fourteen different orifices are recorded.

TABLE III—EFFECT OF SIZE OF ORIFICE

(A) Tests made with mean pressure ratio (r) of 0.92 using methane of specific gravity 0.583.

No. of Orifice	Diameter of Orifice (Mm.)	Thickness of Orifice Plate (Mm.)	Time of Effusion for Air (Seconds)	Apparent Specific Gravity	Error (per Cent)
22XA	.09	.02	587	.580	-0.5
22XB	.09	.02	608	.589	+1.0
21 A	.18	.02	107	.588	+0.9
21 B	.18	.02	107	.590	+1.2
19 A	.25	.02	57	.588	+0.9
19 B	.25	.02	57	.589	+1.0
14 A	.14	.04	160	.575	-1.4
14 B	.14	.04	170	.588	+0.9
16 A	.20	.04	75	.577	-0.9
16 B	.20	.04	84	.585	+0.3
18 A	.19	.06	98	.576	-1.1
18 B	.19	.06	103	.586	+0.5
7 A	.14	.07	145	.582	-0.2
6 A	.19	.07	86	.585	+0.3
8 A	.22	.07	68	.583	0.0

(B) Tests made with mean pressure ratio (r) of 0.99.

22XA	.09	.02	1034	.572	-1.9
22XB	.09	.02	1045	.572	-1.9
21 A	.18	.02	260	.583	0.0
21 B	.18	.02	261	.583	0.0
19 A	.25	.02	134	.586	+0.5
19 B	.25	.02	133	.589	+1.0
30 A	.37	.03	66	.599	+2.7
30 B	.37	.03	65	.598	+2.6
26 A	.15	.04	356	.572	-1.9
26 B	.15	.04	346	.566	-2.9
18 A	.19	.06	249	.571	-2.1
18 B	.19	.06	254	.574	-1.5
27 A	.25	.05	120	.585	+0.5
27 B	.25	.05	120	.584	+0.2
28 B	.07	.10	1772	.539	-7.5
25 A	.12	.09	544	.569	-2.4
25 B	.12	.09	549	.560	-3.9
24 A	.18	.09	255	.579	-0.7
24 B	.18	.09	244	.571	-2.1

The value obtained with orifice No. 30 may be somewhat high, since the high viscosity of the concentrated sulphuric acid used as the confining medium may have retarded the rapid flow of the methane through this large orifice.

Recommendations

a. Types of Apparatus.—The two general groups of apparatus in use may be called the displacement type

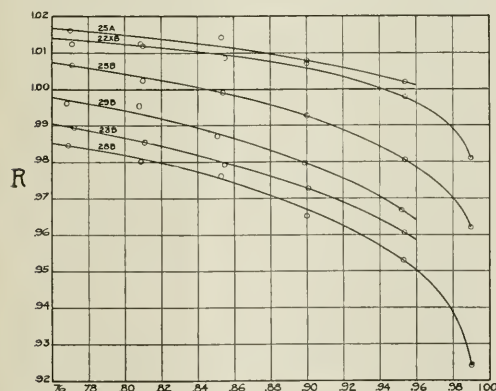


FIG. 4—CURVES SHOWING THE APPARENT SPECIFIC GRAVITY OF "METHANE" (SPECIFIC GRAVITY = 0.583) USING DIFFERENT ORIFICES

and the expansion type respectively. In the first class may be placed those instruments in which one observes the time of effusion of a definite volume of gas actually displaced by the confining liquid. In the expansion-type class may be placed those instruments in which one observes the time required for the effusion of the gas which escapes during the expansion from high to low pressure, the volume remaining practically constant.

The apparatus shown in Fig. 2, is typical of the first class, the space occupied by the effusing gas being filled by the rising column of the confining medium. In Fig. 5 is shown an apparatus of the second type where the driving pressure is obtained almost wholly from the expansion of the effusing gas. In this apparatus the time observed is that required for the pressure in the gas chamber *G* to fall a certain amount as shown by the manometer *M*. The principal advantage of apparatus of the expansion type lies in the small quantity of confining liquid necessary, which is important where mercury is being used.

It amounts to the same thing whether one determines loss in pressure or change in volume, but the relations between the volume of the gas chamber, the effusion time and the effusion pressures are very different for the two types of apparatus. To secure the same effusion time with apparatus of the expansion type as with the displacement apparatus, it is necessary that either the volume of the apparatus or the effusion pressure be considerably increased. For example, if an apparatus of each form has a gas reservoir holding 100 c.c., and if the pressure at the start of a test is 1/10 atmosphere above atmospheric and the pressure at the finish is that of the atmosphere, then using the same orifice on each apparatus, the time of effusion will be approximately eleven times as long with the apparatus of the displacement type as with the ex-

pansion type. To give the same time of effusion would require a total volume in the expansion apparatus of about eleven times that in the displacement type of apparatus. An interval long enough for accurate timing must be obtained and since increasing the time of effusion by decreasing the size of the orifice is only permissible within certain limits, it may readily be seen that an apparatus of the expansion type with an orifice of the proper size might have to be very large and cumbersome in form; this type of apparatus is not recommended.

Two forms of apparatus are suggested in the following paragraphs, the first suitable for use with either mercury or water as a confining medium and the second, a somewhat simplified form, suitable for use with water only. There is nothing essentially new in this apparatus; it is a combination of the most desirable features which have been suggested.

b. Forms of Apparatus of Displacement Type.—The form of apparatus shown in Fig. 6, while especially adapted for use with mercury, is equally suitable for use with water if a few minor changes are made so that the effusion pressure is adjusted to a suitable value. The gas chamber *G* should be made spherical or cylindrical in form, as shown, and should have a capacity of about 150 to 200 c. The smaller cylinder *F* is provided so that when the sample is drawn in at atmospheric pressure, there will be sufficient gas capacity to permit the compression of the gas caused by raising the reservoir *R* to its position and yet leave the mercury a suitable distance below the lower graduation. If water only is to be used in the apparatus, this extra capacity can be reduced accordingly. The gas chamber is connected to the reservoir *R* by means of a rubber tube and to the orifice tube *O* by the glass tube and stop cock as shown. The gas chamber is water-jacketed to maintain a uniform temperature.

Reference marks are placed on the tubes just above and below the gas chamber and the time of effusion is determined by observing the interval required for the meniscus to pass between these two marks. The diameter of the tubes at the top and bottom can be so proportioned that the speed of the meniscus is approximately the same both at the start and finish of a run.

Attached to the upper tube is a three-way stop cock by means of which the gas chamber may be connected either to the side tube *T* for filling or to the orifice which is attached at *O*. This stop cock also may be set so that gas can be passed through the orifice from the inlet *T* while the gas chamber is closed off. This makes it possible to sweep out the orifice tube and connections, and eliminates the uncertainty connected with the use of the apparatus shown in Fig. 1, where the space between the stop cock and the orifice is left filled with a mixture of gas and air which one must assume is swept out by the time observations are commenced. When using water with this apparatus, any moisture condensed in the orifice can be removed by passing dry gas or air from this side tube through the orifice; this will be found to be the most convenient and satisfactory way of drying the orifice.

The orifice tube screws onto the small metal support at *O* into the base of which is cemented the glass tube leading from the stop cock.

The reservoir *R* is supported at a fixed height by a holder and is connected to the gas chamber by a large heavy-walled rubber tube, securely fastened in place. By raising or lowering the bulb, gas or air can be forced out or drawn into the gas chamber; but it is essential that the support be so shaped that the reservoir will be always at exactly the same height relative to the gas chamber so that the effusion pressure is maintained

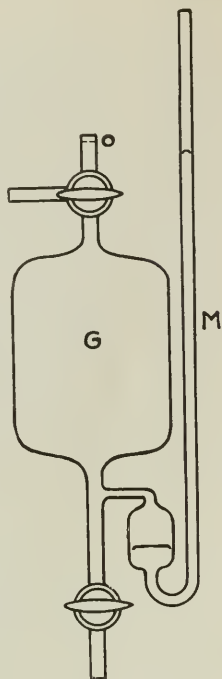


FIG. 5—EXPANSION TYPE OF EFFUSION APPARATUS

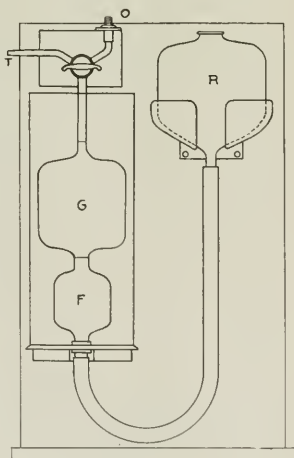


FIG. 6—FORM OF EFFUSION APPARATUS RECOMMENDED FOR USE WITH MERCURY OR WATER

constant. Another support for the reservoir at a lower level is convenient when filling the apparatus with gas.

The apparatus should operate with an effusion pressure of 15 to 20 cm. of mercury at the start of a test and 1 or 2 cm. at the finish; this gives a mean pressure ratio r of about 0.90. If water is being used the pressure should not be reduced below 5 cm. of water at the finish of a test. The length of the tube between the upper mark and the stop cock should be adequate to permit this, if it is intended to use water.

In Fig. 7 is shown a simplified form of apparatus for use with water, which may have certain advantages in some cases.

c. Orifice.—A desirable form of orifice is shown in Fig. 8. The orifice plate, of the form described below, is sealed into the center of a short glass tube, 3 to 6 mm. internal diameter. This tube is mounted with cement in a metal casing, threaded at the end so that it can be attached to the apparatus. The orifice is thus protected from breakage and it can be readily removed for examination or cleaning.

As a guide to the selection of the proper size of orifice, the following general recommendations are made. It should be clearly recognized from the previous discussion of this subject that no definite limits of size can be set but it is believed that the following specifications will aid materially in the construction of a satisfactory orifice.

For apparatus designed to operate with a mean effusion pressure ratio of 0.90 (Fig. 6 used with mercury) an orifice plate 0.05 mm. or less in thickness and having a smooth cylindrical orifice between 0.15 mm. and 0.30 mm. in diameter should prove best adapted for this purpose.

For apparatus designed to operate with a mean effusion pressure ratio of 0.99 (almost any apparatus using water) an orifice plate less than 0.04 mm. in thickness and having an orifice between 0.18 mm. and 0.30 mm. in diameter should be chosen.

c. Standardization.—In control work or where only comparative values are desired on gases of the same general nature, considerable reliance may be placed in the effusion method. Whenever possible it is recommended that a preliminary standardization of the orifice be made. To be significant, it is essential that any standardization be made using a gas of the same character as that to be tested and whose specific gravity has been determined with the necessary accuracy by an independent method. The specific gravity balance for gases described in technologic paper No. 89 of the Bureau furnishes a suitable means of determining the specific gravity for this purpose.

The results shown in Table 1 were thus used to obtain correction factors for the orifices tested with the idea of in-

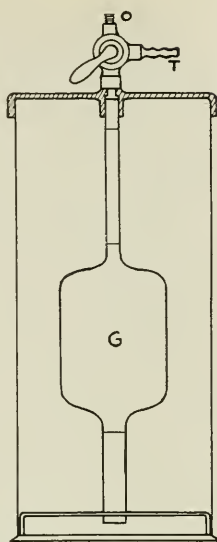


FIG. 7—SIMPLIFIED FORM OF APPARATUS FOR USE WITH WATER ONLY

creasing the precision obtained with them until the method had been more thoroughly investigated. This was practicable since these orifices were being used only with natural gases of the same general character as that employed for the preliminary test. An empirical factor was decided upon which should represent the average amount to be added to the apparent specific gravity to give the correct value; the correction factors recom-

TABLE IV—FIELD TESTS SHOWING USE OF CORRECTION FACTOR

Gas	APPARENT SPECIFIC GRAVITY			CORRECTED SPECIFIC GRAVITY		
	Orifice 4	Orifice 12	Orifice 11	Orifice 4	Orifice 12	Orifice 11
A	.661	.....	.633	.651	.....	.653
B	.668	.....	.635	.658	.....	.655
C	.681	.....	.647	.671	.....	.667
D	.691	.....	.661	.681	.....	.681
E	.687	.674	.648	.677	.679	.668
F	.683	.682	.644	.673	.687	.664
G	.....	.660	.652	.....	.665	.672
H	.....	.679	.666	.....	.684	.686
I	.....	.648	.643	.....	.653	.663
J	.....	.660	.635	.....	.665	.655

Gas "J" was the same as gas "I" except that the test labeled "I" was made at the measuring station and test "J" was made on a sample taken to the laboratory

mended for use were for orifices No. 4, -0.010 ; No. 12, $+0.005$; and No. 11, $+0.020$. Table 4 shows the results of a number of these tests.

e. Operating Directions.—In the preceding sections of this paper, most of the details of operation of the apparatus have been discussed; only a short summary of the operating directions together with certain precautions to be observed will be given here.

The apparatus should be set up and filled with the confining liquid to the proper level; a mark may be placed upon the upper tube at the proper height to aid in reproducing this level.

In filling the apparatus with gas or air, care should be taken to insure an uncontaminated sample by rinsing as many times as may be necessary to obtain constant effusion times in successive tests. The orifice tube and connections must also be filled with the gas sample.

When using a movable reservoir as shown in Fig. 6, care should be taken to replace the reservoir at exactly the same height so that the effusion pressure will not be changed from one determination to the next.

The apparatus should be tested to make sure that there are no leaks in the gas chamber.

Any moisture condensed on the edges of the orifice should be removed by passing dry gas through the orifice. The constancy of the air effusion interval is an indication of whether or not an appreciable error is being introduced from this source.

For a specific gravity determination, several consecutive runs should be made on both gas and air. In general, one should secure three or four intervals which agree within 0.5 per cent, or if the interval be more than two minutes, within one-half second, before the average can be considered as satisfactory. It should be noted that an error of 0.5 per cent in timing makes a difference of about 1.0 per cent in the apparent specific gravity. The accuracy of the stop watch should be checked by comparison with some standard when possible.

In timing, care should be taken to have the eye on a level with the graduation at the time of starting or stopping the stop watch.

Summary

The effusion method of determining gas density, which is based upon the fact that the times required for the escape of equal volumes of two gases under the same pressure through the same small orifice are approximately proportional to the square roots of the densities

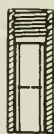


FIG. 8—FORM OF ORIFICE RECOMMENDED

of the gases, was investigated in order to determine the accuracy of the method and its sources of error. In co-operation with a number of men employing this method in the natural gas industry, a series of experiments was made using their apparatus under field conditions. It was found that results in error by more than 10 per cent were not unusual.

The theory of the effusion process was investigated in order to determine the influence of the numerous variables affecting the apparent specific gravity. The relative rates of effusion of air as compared with hydrogen, argon, methane, and carbon dioxide at different pressures and with different orifices were determined. A more detailed treatment of the theory in the light of these results will be given in another paper.

The results obtained from this study together with the observations made on the effect of the effusion pressure, the confining medium, and the shape and size of the orifice were used in determining the most favorable conditions of operation for this method. Recommendations are made as to the most suitable type and form of apparatus for use and specifications given to guide in the construction of the orifice.

Although no results of high accuracy can be expected from apparatus of the effusion type, yet it should serve well for approximate results or for work where relative values only are needed, as in control work.

It has been shown that the apparent specific gravity as determined by this method can be varied within rather wide limits by changing the conditions. However, by the observance of certain precautions in the construction and use of the apparatus, it is possible to secure results accurate to about 2 per cent. The greatest precision is obtained where the physical properties of the gas tested show the least difference from those of air. Some further increase in accuracy and particularly in reliability can be gained by standardizing the apparatus as recommended.

Where a more accurate method is desired, the specific gravity balance for gases described in Technologic Paper No. 89 of this Bureau may be used.

The author wishes to express his indebtedness to Mr. R. S. McBride for his advice and assistance during the course of this work.

Bureau of Standards,
Washington, D. C.

Recent Advancement in Leather Manufacture*

By Allen Rogers

In these days when science is being applied so universally to our manufacturing enterprises, we often wonder what the expert of a generation ago would say if confronted with any of the present-day problems. Even those of us who are in close touch with some special branch of industry often awaken to the realization that while we have been taking a few days' rest, congratulating ourselves upon the knowledge we thought we possessed, such a change has come over our pet that we hardly recognize it. This may be a bit overdrawn, but in the leather trade at least there have been wonderful achievements in recent years and the old-style "rule of thumb" methods have been relegated to the past.

The manufacture of leather, although it dates back to the early days in the Garden of Eden, came down to us practically unchanged for hundreds of years, and it has been only within the past generation that rapid

strides in the direction of progress have been made. The old methods, which were carefully guarded as great secrets and shrouded in mystery, have become public property, and, through the efforts of the chemist, have, in many cases, been discarded as crude, wasteful, inefficient, unsanitary, and highly unscientific.

It is hardly within the scope of this paper to go into the details involved in making all the numberless kinds of leather; it is more essential to point out in a general way where some of the old methods have been improved by modern scientific investigation.

The source of leather is to be found in the skins and hides of animals. Since it is here that leather starts, let us note in passing what science has done to improve the hide. Very few people realize that a hide may be ruined while it is still on the back of the animal, but such is the case. Those of us who were fortunate enough to have been raised on the farm or in country villages will remember seeing the lumps which appeared on the backs of cows at certain times of the year. We will recollect that these lumps grew very slowly and then suddenly disappeared. After the swelling went down, a hole was left to show the havoc wrought by the warble fly or grub. The swollen place was formerly supposed to have been caused by the sting of a fly which by some mysterious method laid her eggs under the hide at this particular point. It has recently been shown, however, by the Department of Animal Industry that such is not the case; that, on the contrary, the fly lays her eggs in the fetlock of the animal and that these eggs are taken into the stomach through the mouth. From thence they pass into the loin, where they mature and work themselves out through the hide. If given proper attention by the farmer, this ravage can be easily overcome, and some states have already taken steps to make this a law.

Another destructive agent on hides is the *tick*. This damage occurs in the flanks, and is often so bad that the entire flank is eaten away. This condition is being obviated by driving the cattle through tanks containing a dilute solution of sulphurous acid.

Scratches and brand marks, which have occasioned great distress to the tanner, are slowly being eliminated.

The hides on removal from the slaughtered animals are usually covered with salt and placed in piles to cure. As a result of this curing it is quite common to find hides which have dark spots on them known as salt stains. These spots cannot be removed and show up later on as black patches. The stain, in most cases, is due to the presence of iron in a ferric condition, indicating that partial iron tannage has taken place.

Within the past five years steps have been taken to eliminate the stain, and much has been accomplished by using a small amount of sodium bisulphite in connection with the salt. Hides so treated are always free from stain.

The common practice for removing the hair is to treat the stock with milk of lime to which sodium sulphide is sometimes added. For removing the lime, it is necessary to employ a substance known as "bate." Formerly the material was hen manure or dog manure, but of late years these have been almost entirely superseded by products of a fermentation or enzyme nature, trypsin being the selective enzyme used.

A new process which does away with liming and bating consists also in using a selective enzyme from the start. This process is meeting with considerable success and seems to have a very promising future. The selective enzyme employed is the same form of trypsin as used in bating, but its application is carried out under different conditions. The process, if it becomes a

*A paper read before the New York Section of the Society of Chemical Industry April 13, 1917, in joint session with the New York Sections of the American Chemical Society and the American Electrochemical Society.

commercial success, will entirely eliminate the liming process and so modify the bating that the two operations will be accomplished at one and the same time.

When Augustus Schultz, an American chemist, discovered the two-bath chrome method of tanning leather, he gave to the world a process which revolutionized the whole industry, and had more to do with placing tanning on a scientific basis than any other cause. Not only has this discovery resulted in the bulk of upper leather being of chrome tannage, but it has led to other great achievements. Chrome tannage was at first applied only to goat-skin, but with a better understanding of the use of chromium salts modified processes are being applied to all kinds of stock. One of the latest uses is in making white washable shoes so largely worn at present by the fairer sex. Indestructible sole leather is being made by a chrome combination process, but this does not meet with favor from the shoe manufacturers because its wearing quality is too great.

Washable glove leather is a chrome combination bath of recent introduction and is meeting with increasing popular favor. Formaldehyde is being used as a tanning material, for light leather, when a very white and washable leather is required, but it has its limitations.

Only a few years ago all manufacturers of heavy leather were using hemlock or oak bark as a tanning material. To-day the old-style bark tanning has been almost entirely superseded by the more modern extract plant. That is, barks and woods of various kinds are being treated to obtain their tannin content, and the concentrated extract obtained is sold direct to the tanner. One of the extracts used to-day in greater amounts than any other is quebracho. Ten years ago this material was almost unknown to the American tanner, while at present thousands of tons are being consumed annually. In place of the time-consuming processes which took from one year to eighteen months we are making the bulk of our sole leather in from sixty to ninety days with a resulting leather that is superior in wearing quality, style and ease to the old bark-tanned product.

In the manufacture of paper a by-product has been going to waste for many years in the spent sulphite liquor. This liquor is now being utilized in the manufacture of heavy leather where for certain purposes it is giving very satisfactory results.

Patent leather to-day is not the same weak and brittle product it was a dozen years ago. The reason for this is that the method of treatment is such that it will retain the finish and yet remain strong, while at the same time the finish is as flexible and applied only in thin coats.

With the increased cost of raw material, ways have been devised to utilize the portion which formerly went to waste or brought only a very small return. Thus splits, which five years ago were a drug on the market, are now being converted, by means of dope and other finishes, into a fair grade of shoe upper leather.

Owing to the scarcity of hides and skins and the increased demand for leather, many skins are now being tanned that were formerly considered to be worthless as leather. Thus to-day we find that the hides of whales and skins of fish are being converted into a marketable product.

As a result of the scarcity of hides and skins, various substitutes have been brought forward, so that we have imitation leather for furniture and automobile leather, mat and glaze finished lineoleum products to take the place of upper leather and finally several sole leather substitutes. With all of these, however, the old saying still holds good: There is nothing like leather.

Nitrate Industry in Chile

In our issue of March 1, 1917, pp. 253-259, we published an article on the nitrate industry in Chile by I. Berkwood Hobsbawn. A paper on the same subject by Mr. Hobsbawn and J. L. Grigioni, as joint authors, was presented at a meeting of the London Section of the Society of Chemical Industry and is published in the journal of the society for Jan. 31, 1917. From this paper we take the following information, which describes two of the processes in greater detail, to supplement our previous article:

The year 1912 witnessed the initiation of two processes which are now undergoing commercial development in Chile and which merit detailed description, namely, the Butters process and the Gibbs process.

BUTTERS PROCESS

The following details of the Butters process were taken by the authors from a description given by Mr. J. T. Humberstone at the Mining Congress held in Santiago de Chile in April, 1916, supplemented by reports and descriptions received from private sources.

The Butters process was developed by the Butters Vacuum Filter Co., assisted by Mr. J. T. Humberstone in Oficina Agua Santa, Tarapaca, Chile.

It is based on the use of the Butters vacuum filter as the means by which the nitrate and salt solutions are removed from the insoluble matter. It is proposed to reduce the whole of the raw material to sufficient fineness, by grinding in ball mills with hot weak nitrate solution, that it will be amenable to treatment in the standard Butters filter. After grinding, the pulp is further heated by steam coils, in order to cause solution of the nitrate, air agitation going on the while.

In the Agua Santa works the fines (11 per cent nitrate content) are mixed with liquor (150 grms. nitrate per liter) in the proportion of three of solid to one of liquid. The hot pulp is then filtered in the Butters vacuum filter and a certain proportion of liquor is extracted in this way. This liquor is of varying strength, depending on the amount of weak liquor (and strength thereof) which is used for the extraction and the proportion and richness of the raw material used with it.

The inventors claim that it is possible to prepare a liquor, by this means, which can be sent direct to the crystallizing tanks, but so far this claim has not been substantiated in practice. In fact, the inventors state that it is preferable to work for the preparation of a liquor containing about 450 grms. of nitrate of soda per liter, which would show a density of about 75 deg. Tw. and temperature of about 80 deg. C. Such a liquor

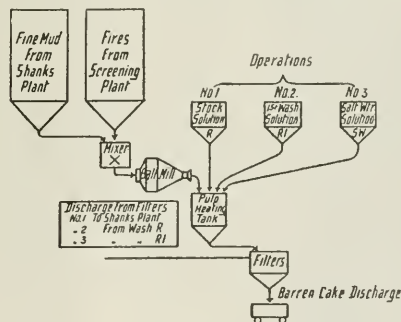


FIG. 1—DIAGRAM OF FILTER TREATMENT OF FINES AUXILIARY TO MAIN (SHANKS) PLANT—BUTTERS SYSTEM

would have to be concentrated in evaporators (a liquor generally considered good enough to go to the crystallizers will contain about 750 gr. per liter of nitrate of soda and 120 gr. per liter of salt, and have a density of 104 deg. Tw. at 102 deg. C.), separated from the insoluble salt, and crystallized in order to regain the nitrate, but the Butters process has not considered the necessity of evaporators so far. They prefer to use the process as an auxiliary to the existing system. The cakes are subsequently washed twice with weakening liquors; the washing is claimed to be by displacement only and the final wash is done with salt water (saturated brine) which leaves the cakes with about $\frac{1}{4}$ per cent nitrate of soda. The cakes are then discharged. The different liquors obtained from each successive displacement wash are used in the next round, the whole forming a cycle of operations, at one end of which the strong liquor is removed, while at the other end the cold brine "displacement" wash takes place.

As it is being used at present in Oficina Agua Santa, the Butters process acts as an auxiliary process to the main Shanks Maquina, and the results claimed so far are sufficiently good to restrict the working of the process to these lines.

The process, which has now worked there for nearly a year, consists in screening the whole of the crushed product in order to remove 20 per cent of it as fines passing a 6 mm. mesh. These fines are treated by the Butters process as described above.

The coarser material alone is treated in the boiling tanks, as formerly, and the liquors obtained from the Butters process are introduced into the cycle of operations in the Shanks system, the whole process being assisted by evaporators previously installed in the works.

By the combination of Shanks process, Butters fines treatment, and evaporators, material of 14.5 per cent nitrate content is worked successfully with an efficiency of 64 per cent as against an efficiency previously obtained by the Shanks process plus evaporators alone of about 50 per cent. Working costs appear to be fairly high, but in view of the increased yield of nitrate obtained from the same amount of raw material the combination of processes must be admitted to have met with success. As to what measure of this success is due to the Butters system alone it is difficult to state, as it is claimed that by the mere elimination of fines alone the lixiviation in the Shanks system is so very considerably improved as to increase the yield therefrom from 50 per cent to 61 per cent.

Without the use of evaporators it is doubtful whether any such improvement would be shown, and it is more doubtful still whether the strengthening up of the liquors produced by the auxiliary process by passing them over the coarse material in the Shanks system is a satisfactory way of using these liquors, without recourse to evaporation.

But it is certain that there is a limit to the amount of such liquor which could be strengthened up in this way, without evaporation. If it is assumed that 75 per cent of the total material is fine and the other 25 per cent coarse, the fines will contain 72 per cent of the total nitrate, of which 90 per cent will be extracted and made into weak liquor; the coarse will contain 25 per cent of the total nitrate only, of which but 65 per cent at the outside can be extracted in the Shanks Maquina. This means that there will not be enough nitrate available in the coarse to bring the liquors from the fines to crystallizing strength.

As the process stands at present it is claimed: (1) A 90-95 per cent extraction of nitrate from raw materials as low as 11 per cent in average and the ability to pro-

duce liquors which can be directly crystallized for their nitrate of soda content. (2) That this can be carried out at low labor and fuel cost. As we have pointed out, it has not so far been worked in this way, but only as an auxiliary process to the Shanks system combined with evaporators, in which combinations its actual success, cost of operation particularly, is obscured by other factors.

The process is still in course of trial and doubtless will be improved in many ways and eventually perhaps successfully applied to certain of the particular needs of the industry of the future.

GIBBS PROCESS

Early in 1912 Messrs. Gibbs & Co. of Valparaiso dispatched their engineer and chemist, the writers of this paper, on a tour of investigation through the U. S. A., France and Germany in order to gather as much information as was possible on methods used in other industries, so as to be able to develop the Chilean nitrate industry on more modern lines.

This resulted in the initiation of a process, on completely new lines, consisting of a new method of lixiviation and a process of evaporation which combined the regaining of the nitrate direct together with the separation of the sodium chloride. The details of the process were worked out in England, the theoretical part at the Manchester School of Technology, and later at the experimental laboratories of Messrs. G. T. Holloway & Co., and the practical part at the latter laboratories and near Mitcham, where an evaporation plant was erected on the principle worked out in conjunction with the Kestner Evaporator & Engineering Co., Ltd., of London. The results were completely satisfactory and a demonstration was given in July, 1914, before the representatives of the nitrate industry and the Chilean Ambassador and his suite.

The Gibbs process aims at the treatment of the raw material as two separate sections in the problem. (1) Lixiviation of raw material; (2) Concentration of liquors from 1; and No. 2 may be subdivided into (2a) Separation of salt contained in the liquors from 1; (2b) Separation of nitrate of soda.

The Gibbs treatment of raw material is based on the observation that in typical caliches, both of high and low grade, the soluble material is the binding agent by means of which a conglomerate of insolubles is held together.

This insoluble material consists of stones and sands together with finer matter such as clay, oxides of aluminum and iron, etc., which may be considered to be slime formers. (It is these slimes which prevent the free lixiviation of the mass and complete removal of liquors therefrom, and the removal of these slimes is the prime object of the Gibbs lixiviation scheme.) The stones and particles of sand, etc., are quite in their native state and are free from soluble matter with the exception of what is crystallized round them. If, in the laboratory, the raw nitrate-bearing material is treated without any grinding or breaking at all, with dissolving agents (hot water) in such a way as to wash out all of the soluble contents, the insoluble remainder, when ground to an almost impalpable state, will show practically no further trace of soluble matter. The results of the washing will be to produce a stony, sandy mass which is quite valueless for nitrate content.

A reference to the screening tests, Table I, on two extreme caliches will show what occurs after complete lixiviation.

It is on this principle of separation and removal of slimes during lixiviation that the Gibbs system of lixiviation is based and the objective is reached in practice

in the following way. The raw material is crushed as usual to about 2 in.-3-in. and fed into a mill together with nitrate solution at about 50 deg. C.

This mill, worked without balls or pebbles, acts purely as a disintegrating mill, in which the raw material is reduced to its ultimate particles with the minimum of grinding or sliming action.

The pulp is passed continuously from the mill to a series of classifiers in which the lixiviation action takes place in counter-current.

Assuming four classifiers in the series, water is fed into No. 4 where it washes the already thrice washed insoluble matter and the wash from this is passed for-

intimate contact with the weaker liquors. The action takes place in four stages and the final insolubles, passing out of No. 4 stage or classifier, are in the form of clean sand, gravel, stones, etc., which do not contain, locked up in crevices in the particles, any more than $\frac{1}{4}$ per cent nitrate of soda. As the mass can be easily washed and drained the loss of nitrate in this part ought to be little more than that quantity. Having extracted the nitrate and disposed of the bulk of the insoluble matter, the liquor obtained from No. 1 is a saturated solution of nitrate and salt together with the other soluble salts and containing the -80 insoluble viz., fine sands and slimes.

It will be noted that the classification aimed at is not the fine classification desired in most mining propositions, and the principal object, that of removing from the insolubles the fine portion, permits of the easy and cheap washing and disposal of the rest of the bulk. As will be seen from the screen tests shown (taking the classification as separating the + and -80 mesh) the amount separated as -80 will be in the case A 32.82 per cent of the insolubles or 8.6 per cent of the total raw material, and in case B 14.7 per cent and 9.88 per cent respectively, and these quantities have to be filtered out of the liquor obtained from No. 1 classifier. This filtration is carried out by means of the Oliver continuous vacuum filter, which is a revolving drum of which about one-third of the circumference at a time is dipping under the liquor to be filtered.

ward to No. 3 which it washes and in turn is passed to No. 2 and finally to No. 1. The insoluble matter passes from No. 1 to No. 2 and onward to No. 4 whence it is discharged.

The object of the classification is twofold. In the first case the classification is for the separation of the slime-forming fines, together with a proportion of fine sand, in effect the washing off from the bulk of the raw material that portion of it which is about -80 mesh. In the second case, assisted by a rise of temperature to whatever is decided as convenient, solution of nitrate is brought about by intimate contact between wash liquors and particles of raw material.

The liquor coming from classifier No. 1 contains then all the -80 insolubles while the +80, together with adherent solution (from which it is drained as much as possible on its passage to No. 2 classifier) and undissolved nitrate, passes to No. 2 where it meets the weaker wash from No. 3. Slight classification may take place here, but essentially the function of this and the following classifiers is to bring the solid particles into in-

timated contact with the weaker liquors. The drum is divided into segments which in turn are connected to vacuum and compressed air and the operation is mechanically controlled by means of a disc valve, the cake being sucked on by vacuum while that part is dipping into the liquor (kept agitated), sucked dry for part of the time it is out of the liquor, spray washed and dried also under vacuum, and finally scraped off after being loosened by compressed air.

The net result of the operations is that about 10 per cent of the raw material is treated by the more expensive filtration process while the rest of the insolubles, case A 17.6 per cent of the raw material, case B 57.32 per cent of the raw material, is washed quite free from its soluble nitrate contents and discharged without any filtration or expensive treatment. The advantage in the case of low grade material is obviously enormous.

The process has been designed to obtain a liquor containing about 450 grams of nitrate of soda per liter and about 200 grams of salt, with about 50 or 60 grams of other soluble salts, as calcium and magnesium sulphate, chloride, and nitrate, sodium sulphate, etc.

By increasing the temperature of operation a stronger liquor may be obtained, but this increase in strength by rise of temperature is subject to economic limitations which it is intended shall be studied on the large scale on the spot.

TABLE 1—SCREEN TEST AND ANALYSIS OF CALICHES

Mesh 1 Mm.	% of Insolubles	A	B	Analysis	A	B
Plus 5	Sands and stones	21.75	45.30	Sodium nitrate	24.93	9.66
Plus 8		8.39	9.10	Sodium chloride	25.30	9.87
Plus 10		3.06	4.30	Sodium sulphate	2.20	8.27
Plus 20		10.71	11.70	Mag. chloride	7.27	...
Plus 30		5.34	4.40	Calcium chloride	3.37	...
Plus 40		5.72	4.40	Calcium sulphate	...	3.97
Plus 80		12.21	5.60	Other solids	10.73	1.00
Plus 100		6.10	2.20	Total solids	73.80	32.77
Minus 100	Sands	13.74	6.60	Insolubles	26.20	67.23
Minus 100	Slimes	12.98	5.90	Total	100%	100%

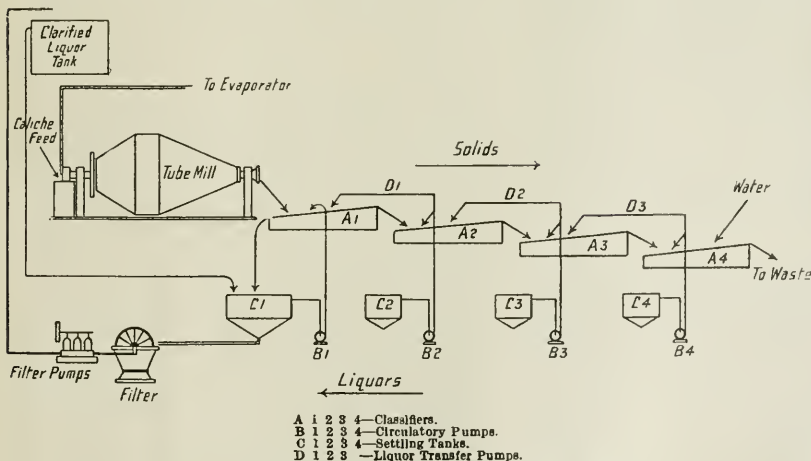


FIG. 2—GIBBS PROCESS. DIAGRAM OF LIXIVIATION SYSTEM

The actual experiments on the large scale show the losses to be approximately $\frac{1}{2}$ per cent nitrate on the +80 mesh and 2 per cent nitrate on the -80 mesh, or out of 1000 tons caliche A (24.93 per cent):

262 tons insolubles would contain 86 tons slimes at 2%	=1.72 tons
262 tons insolubles would contain 176 tons coarse at $\frac{1}{2}$ %	=0.88 tons
	2.60 tons

Out of a total of 249.3 tons nitrate of soda hence 246.7 tons is recovered or 98.9 per cent yield.

In case B—

1000 tons of material 9.66% nitrate:	
98.8 tons slimes at 2% nitrate	=1.976
573.2 tons coarse at $\frac{1}{2}$ % nitrate	=2.866
	4.842 tons nitrate

Out of a total content of 96.6 tons nitrate of soda the yield is 91.758 tons or 95 per cent.

As mentioned above, the standard liquor aimed at in the lixiviation system above outlined contains nitrate of soda 450 grams per liter, salt 200 grams, other solubles 50 grams, water 650 grams; total 1350 grams per liter.

The evaporation system is divided into two sections, one aiming at the almost complete separation and recovery of the salt, while the other recovers the nitrate of soda direct in the form of crystals.

In the first part the evaporation is carried out as a double effect. In the lower temperature effect the evaporation is done under vacuum at about 80 deg. C. and the liquor from this goes to the second, the higher temperature effect, for evaporation at about 124 deg. C. under normal atmospheric pressure.

At this temperature practically the whole of the salt is rendered insoluble and the plant, a modification of the well-known Kestner evaporator, is arranged so as to insure the transference of the desalted liquor without loss of temperature (and consequently nitrate of soda) and completely free from suspended salt, to the nitrate crystallizer, which is a vacuum effect without calandrias.

Here by cooling and self-evaporation under vacuum the nitrate crystallizes immediately and is removed from the coded bottom by a screw and dried in hydro-extractors. The apparatus is shown in accompanying figure and works approximately as follows: Effect No. 1, which is worked under a suitable vacuum, causes the deposition of about 50 per cent of the total salt contents of the liquor. This salt is removed by a mechanical screw and sucked dry and washed in a vacuum filter. The liquor from No. 1 passes to No. 2 where the maximum temperature desired is reached. This brings about the completion of the desalting and the liquor, now boiling at or about 124 deg. C., is transferred to No. 3, a vacuum effect without calandrias where the nitrate is deposited.

The salt from No. 2 effect is periodically removed by means of the specially designed filter box, which permits of the salt being washed after draining and disposed of with the minimum loss of nitrate of soda. The steam produced in effect No. 2 is used for procuring the evaporation in No. 1 and all surplus steam is diverted to a preheater or to the lixiviation plant.

The advantages claimed by the Gibbs process are: 1. Cheapness of installation. 2. Ability to treat cheaply and effectively low ley caliches with an efficiency of 90 per cent extraction over all. 3. Ease of control of process. 4. Direct crystallization of nitrate, insuring ability to trace losses and remove their causes almost at

once. 5. Greater control over the working of the nitrate deposits.

Advantage No. 5 should give an incentive to the development of the mining of nitrate of soda. Many causes, chief among which is the necessity for hand selection of the material used today, have conspired to prevent the development of the use of mechanical drills and shovels in the Chilean nitrate fields.

It is to be expected that with the advent of the newer processes no longer necessitating the specially hand selected material, these causes will automatically disappear and the more rational mining come into its own.

The mother liquor from the hydro-extractor is periodically examined for lime and magnesia content, and treated for the conversion of these into sodium salts when necessary, separated from the insoluble magnesia and lime, and returned to the system, being introduced into either the high or low temperature effect according to circumstances. Periodically the accumulated iodine salts will be examined and the iodine extracted by precipitation in the usual way.

The cost of a complete installation of the Gibbs process is estimated to be about one-half that of the present type of plant, and it is expected to be able to treat material of as low a ley as 10 per cent with 90 per cent efficiency, at a cost reduced in a marked degree. There can be no comparison of costs when working with 10 per cent material with the Gibbs process because the present type of plant cannot deal with it at all.

The first Gibbs plant is now being constructed for the Fortuna Nitrate Co. for their Oficina Celia, Antofagasta, Chile, and it is expected to commence actual work within the next nine months.

Synopsis of Recent Metallurgical and Chemical Literature

Blast Furnace Plant

Power Plants for Blast Furnaces and Steel Mills.—

In a paper presented before the Engineers' Society of Western Pennsylvania and printed in the *Proceedings* of the society for March, 1917, RICHARD H. RICE and SANFORD A. MOSS, engineers of the General Electric Company, Lynn, Mass., discuss the turbo-blower for supplying blast, and give a cost comparison of a power plant using these blowers and one using gas engines. They state that the use of turbo-blowers for blowing, and of turbo-generators for generating electric power for steel mills from surplus gas gives a type of power plant which is competitive with a plant using gas directly in gas engine-driven blowers and generators. Complete tabulations of the cost of operation of each type for four blast furnaces are given. The first costs are found, and from them are computed the fixed charges at the rate of 13 per cent. To this is added running charges and cost of make-up coal. A small amount of make-up coal is used in the gas-engine plant to equalize poor gas and excess power demand, and a somewhat larger amount is used in the turbine plant. The authors claim that the gas plant first cost is about two and one-half times the steam turbine plant first cost, so that, taking account of fixed charges, the total operating cost of the gas plant is about twice that of the steam turbine plant. They state that this item of first cost is so influential that, regardless of exact details used in comparisons, a steam turbine plant will always turn out to have lower total charges than a gas-engine plant if fixed charges are included. An extended discussion by representative engineers from large steel companies, gas engine and equipment companies follows the paper, and differing opinions are given as to the value of the turbo-blower in the blast-furnace plant.

Melting of Metals

Melting of Brass.—At the meeting of the Institute of Metals in London the latter part of March, several papers were presented on the melting of non-ferrous metals. One of these abstracted in *Iron and Coal Trades Review* was on the melting of brass, describing a new furnace. The authors are H. M. THORNTON and HAROLD HARTLEY. The furnace referred to is a Richmond 70-lb. gas-fired crucible furnace of the preheating type. The gas and air mixture is admitted through a suitable blast burner and the lower portion of the combustion chamber, and is burnt in the annulus between the crucible and the furnace wall. The gases, after traveling around the pot, are directed through the metal preheating chamber, and then pass on to the air pipes, and finally to the flue. This arrangement enables a high degree of preheat of the metal to be obtained. The top of the metal chamber is on a level with the top of the pot chamber, and is closed by a pair of lids. With this construction the operator has not to lift his metal above the foundry floor level, and the transference of preheated material to the crucible is done with ease. The lower portion of the wall of the combustion chamber is constructed of suitably shaped blocks of a specially refractory nature to enable greater resistance to be offered to the combined action of high temperatures and spilt metal. The bottom of the chamber can be removed for the recovery of spilt metal. In regard to cost of operation the authors have the following to say:

"In working with coal-gas the fact must not be overlooked that in terms of B.t.u. available the fuel is costing from four to five times as much as coke, assuming the gas supply to give 500 B.t.u. per cubic foot net at a cost of 2s. per 1000 cu. ft., and even with water-gas the fuel is considerably more costly per B.t.u. than the coke which it is intended to replace. Starting with this disadvantage the furnace manufacturer has either to obtain a markedly greater thermal efficiency out of his appliance, or to effect economies in other directions." They have used in their work with brass and copper a pouring temperature about 100 to 150 deg. above the liquidus. The following table gives the results of six melts, representing a typical run:

	Gross Consumption per Lb. Metal Melted, Cubic Feet	B.t.u. per Lb. Metal Melted
Average for 6 melts	2.25	1203
Average for 12 melts	1.92	1631
Average for 15 melts	1.86	996
Average for 20 melts	1.79	962

From rough calculations it was determined that the thermal efficiency of gas furnace is five times that of the coke furnace. Increased life of pots and increased output are also important factors.

Melting Metals in the Electric Furnace.—A paper on this subject was read at the March meeting of the Institute of Metals (London) and abstracted in the *Chemical Trade Journal and Chemical Engineer*, March 24, 1917. The authors are H. C. GREENWOOD and R. S. HUTTON. The authors have had occasion to note the great improvement in working qualities of nickel-silver alloys melted with gas over similar alloys melted with coke. Electric heating should show an even greater advantage. For non-ferrous alloys a construction of furnace suitable for using ordinary crucibles is especially desirable. The electric furnace designed by the authors takes a 100-lb. plumbago pot. The electric heating is quite independent of the crucible, the furnace being of the "resistance" type, the current passing through upright carbon rods situated near the inner face

of the walls of the furnace; the heating is thus under perfect control. Actual tests carried out with a charge of 90 lb. of nickel-silver took three hours for the first heat and one hour and thirty-five minutes for the second heat; the energy consumption was 53.6 and 29.2 kw.-hr. respectively. The principle advantages to be expected from electric heating are: (1) Absence of gas currents, reducing spelter losses and making the maintenance of a reducing atmosphere relatively simple; (2) lower sulphur contamination; (3) greatly enhanced life of crucibles; (4) improved quality of metal. The further development of this furnace was postponed owing to the difficulty of obtaining carbons in this country at the commencement of the war. A description of the work in its incomplete form is, however, given with the object of encouraging others to devote their attention to the development of a commercially practical electric furnace.

Melting Metals with High-Pressure Gas.—Recent practice in England in the use of high-pressure gas for metal melting is described in a paper of C. M. WALTER, read at the Institute of Metals meeting. An abstract is given in *Iron and Coal Trades Review* for March 23, 1917.

The application of town gas for the melting of brasses, bronze and other alloys has during the last few years received considerable attention, and at the present time, in many localities where gas can be obtained at a reasonably low rate, it is being largely used with considerable economy in melting costs. Many excellent types of furnaces are now obtainable, and crucible furnaces having pot capacities from 50 lb. to 800 lb. are now commonly met with. Such furnaces may be classified into three distinct groups, according to the manner in which the gas is applied, as follows:—A. Furnaces designed for working with gas at the ordinary town pressures of 2 to 3 in. water-gage, and fitted with atmospheric burners. B. Furnaces employing gas at ordinary town pressures with air under a positive pressure of usually 1 to 3 lb. per square inch. C. Furnaces in which gas is employed at a pressure considerably higher than the ordinary pressure, and fitted with either—(a) atmospheric burners; or (b) burners designed for working with air under a moderate pressure of about 20-in. water gage. Under heading C, which comprises the furnaces specially dealt with in this paper, there are the following classes: (1) (a) Pit furnaces for melting brasses and bronzes for sand-castings, ranging from 60 to 200 lb. capacity; (2) pit furnaces for melting brasses, bronzes, and cupro-nickel, for strip and billet castings having pots of capacities up to 200 lb.; (3) pit furnaces for melting aluminum alloys, having pots of capacity 200 to 600 lb. (copper); (4) small furnaces for melting precious metals having pots of capacity 10 oz. to 200 oz.; (1) (b) furnaces for melting brasses, bronzes, pure nickel, and for melting non-ferrous metals generally where extremely high temperatures and high speeds of melting are required. An equally important application of the use of high-pressure gas is in connection with the melting of aluminum and its alloys, and for the production of fine quality castings and high-tensile alloys of this metal; owing to the cleanliness, convenience and ease of temperature control, the high-pressure gas furnace may be said to have firmly established itself in this connection on the score of both efficiency and economy. For the melting of such alloys on a large scale, the furnace usually employed is one constructed on similar lines to those already described, heated by means of high-pressure injector burners, with gas at a working pressure of about 12 lb. per square inch. These furnaces are usually built to take pots of capacity 500 to 600 lb. (cop-

per), the metal being ladled from the melting-pots into smaller pots for carrying to the molds. With such plant it is found that, in the case of the melting of the ordinary commercial aluminum alloys, during a working day of twelve hours 10 heats of metal of about 200 lb. each can be obtained from each furnace, with a gas consumption of 12,000 to 14,000 cu. ft. per ton of metal melted.

Coal-Gas for Melting Non-Ferrous Alloys.—The results of tests on coal-gas as fuel were described in a paper read by GEORGE B. BROOKS at the Institute of Metals meeting in London. An abstract is given in *Iron and Coal Trades Review* for Mar. 23, 1917. The results are summarized in the following questions:

- (1) Would ordinary coal gas give a temperature that was sufficiently high for casting cupro-nickel?—No difficulty at all was experienced in attaining a temperature of 1400 deg. C.
- (2) What was the relation between the coke-fired furnace and the gas-fired furnace from the following standpoints?—
 - (a) *The Relative Cost of Melting Per Ton of Alloy Produced.*—Average cost of melting with high-grade metallurgical coke, 36s. 4d.; with gas at ordinary Sheffield rates (1s. 9d. per 1000 cu. ft.), 31s. 9d.; at the preferential rate allowed for gas engines (1s. 4d.), 24s. 2d.
 - (b) *Relative Speed of Melting.*—It was under this heading that the great advantage was shown by gas over coke. The same weight of metal (56 lb.) can be melted in the gas furnace in 52 minutes which required 82 minutes in the coke-fired furnace. When this advantage is translated into commercial practice, the advantage is still more striking; for on the two-day test with the gas furnace it was possible to obtain 12 heats in less than ten hours, whereas in an ordinary working day of ten hours it is rarely possible to get more than five heats from a coke-fired furnace.
 - (c and d) *The Life of the Crucibles and the Wear and Tear of Lining and Burner.*—Graphite crucibles of the same make have a longer life in properly controlled gas-fired furnaces than in coke furnaces (average 17.6, as against 12.5 heats). The lining of the furnace stood the test satisfactorily, and the condition of the burner was also quite good.
 - (e) *Mechanical Losses.*—The percentage loss was found to be 0.40, which represents a substantial saving compared with coke furnaces (1 per cent with the best practice).
 - (f and g) *Labor and Capital Charges.*—The labor charges per ton of metal produced would be less with the gas-fired furnace in a large installation from the fact that a larger number of gas furnaces can be controlled by the same staff, and the output would be higher in the case of such furnaces. There would be very little difference in the capital cost of an equal number of furnaces of the same output.
 - (h) *Quality of Product.*—The cupro-nickel was tested at every stage, and was found to be satisfactory. The ultimate test in the actual production of bullet sheaths showed that the material was equal, if not superior, both as regards quality and number of failures, to any that had been produced in coke-fired furnaces.

The absence of ashes, the elimination of the wasteful process of "slagging," the economy in fuel under control, the reduction of impurities in the fuel, and the speed of melting are factors of considerable importance to the manufacturer.

Metal Melting at the Mint in England.—A paper presented before the recent meeting of the Institute of Metals by W. J. HOCKING describes the melting of gold, silver, bronze and cupro-nickel. An abstract is given in the *Chemical Trade Journal and Chemical Engineer*, Mar. 24, 1917. The castings are about 2 ft. long and varying in width and thickness. Small charges are used, for gold-copper about 2800 oz., and for silver-copper about 6000 oz. For bronze and cupro-nickel about 400 lb. are used. Coke furnaces were in use until 1910. The melting department was then enlarged and rebuilt, and, as the result of a series of experiments, furnaces, fired by low-pressure gas and air, were introduced. Urgent demands for gold coinage arising during the rebuilding operations, an improved gas-melting plant was installed in a disused smithy with a floor space of 860 square feet only. In the course of a year and nine months 874 tons of standard gold, amounting in value to 111 millions sterling, were melted. As a test of the efficiency of the four experimental furnaces in use, a continuous run of melting was maintained for 27¾ hours. The total amount of gold melted was 257,052 oz., or 7.87 tons, which is upwards of a million sterling in value. There were 102 pourings, and the consumption of gas was 32,000 cubic feet. The furnaces were in a condition to resume work on the following day as usual. The furnaces in the new buildings are designed to burn gaseous fuel, gas being supplied at 3-in. pressure and air at 2½-lb. pressure. The burner adopted is of the Brayshaw type, with a specialized form of attachment to the furnace. Two sizes of furnaces were constructed in separate rooms, one for melting gold with crucibles of a capacity of 2800 oz. and one for other metals with crucibles taking 400 lb. The large furnaces are sixteen in number, and are built of Stourbridge firebrick, each well being 19 in. in diameter and 32 in. deep. The wells are lined with circular firebricks, 3 in. thick, jointed with a refractory material composed of carborundum, firesand, and silicate of soda. The furnaces are constructed in line towards the center of the room, and arranged in two batteries, one of ten and one of six. The brickwork is braced together by a framework of iron bars to resist expansion, but is not enclosed with iron casing. The tops, however, are covered with cast-iron plates 1 in. thick, bedded upon a half-inch layer of asbestos cement. The rate of gas consumption by the sixteen large furnaces is about 15,000 cubic feet per hour. A six-inch service pipe is used for delivery, and this provision is well in excess of the requirements, an ample reserve being considered essential in order to obtain uniformity in results. Records of the costs incurred under the two fuel systems are available for comparison for extended periods. During five years, 1911-16, coinage metals to an amount of 9900 tons were melted with a total gas consumption of 121 million cubic feet. The average consumption per ton melted was 12,200 cubic feet, and the cost of the gas was 20.58 shillings. The general results showed that with this fuel, as compared with coke, the rate of output was more than doubled, the greatest increase occurring in the case of metals with high melting points. Substantial economies were also made in the actual cost of fuel, of graphite goods, and of labor. The total economy effected under these three heads was at the mean rate of 25 per cent.

Carbides

Researches on the Carbides of Aluminium, Copper and Nickel.—In the July-August number of the *Revue de Metallurgie*, 1916, pp. 155 to 156, is given an extract of some work on aluminium, copper and nickel carbides by BRINER and SENGLET. Aluminium carbide heated in

air decomposes according to the equation $\text{Al}_2\text{C}_3 + 6\text{O}_2 = 3\text{CO}_2 + 2\text{Al}_2\text{O}_3$. In the absence of air the product dissociates according to the following equation $\text{Al}_2\text{C}_3 \rightleftharpoons 4\text{Al} + 3\text{C}$. In this last case the quantity of aluminium found after the reaction will always be less than the theoretical amount due to a loss by volatilization and by the formation of aluminium slags or other compounds by the attacking of the receiver in which the material is heated. Concerning the reaction velocity the authors obtained the following results:

Dissociation in Air		
Heating Time in Hours	Temperature	Per Cent
7 hr. 00 min.	900 deg. C.	100
1 hr. 30 min.	900 deg. C.	99.5
2 hr. 30 min.	900 deg. C.	98
1 hr. 40 min.	700 deg. C.	95
2 hr. 30 min.	540 deg. C.	85
Dissociation in Vacuum		
1 hr. 00 min.	540 deg. C.	22
1 hr. 30 min.	540 deg. C.	42
4 hr. 00 min.	540 deg. C.	70

According to these figures the decomposition is not proportional to the time or the heating. The authors claim this to be due to the nature of the reaction and to the heterogeneity of the surroundings. In the first case the reaction velocity depends a great deal upon the ease with which the oxygen has access to the reaction components. From the above it may be seen that the velocity of decomposition at 540 deg. C. is greater in the presence of air than in vacuum. The opposite is the case with such carbides as calcium carbide heated to 900 deg. C.

To show that the reaction $\text{Al}_2\text{C}_3 \rightleftharpoons 4\text{Al} + 3\text{C}$ is reversible, the authors endeavored to prepare the carbide under the same conditions as were used for the decomposition of the carbide. On heating powdered aluminium in vacuum with a large excess of powdered sugar carbon at 500 deg. C. for two hours only minute amounts of carbide were formed. At 750 deg. C. a slight formation of carbide was observed. At 900 deg. C. the reaction was practically complete. The reaction therefore is reversible. In equilibrium, the system consisting of aluminium carbide, aluminium and carbon shows the presence of the carbide at low temperatures and the elements aluminium and carbon at high temperatures.

The carbide of nickel used in the tests was made by heating very pure nickel on a bed of sugar carbon enclosed in a graphite crucible in an arc furnace. After fusion the product is poured into cold water or into an oiled mold. The product thus obtained on treating with hydrochloric acid does not evolve gaseous hydrocarbons, nor are liquid or solid hydrocarbons formed. Hydrogen is given off and some graphite is formed. Chemical analyses gave no results and recourse had to be taken to microscopic studies. The prepared samples were dipped into concentrated nitric acid for ten seconds and then examined. According to the metallographic examinations the carbide of nickel is formed according to the equation $3\text{Ni} + \text{C} = \text{Ni}_3\text{C}$ under conditions of maximum concentration and a temperature in the neighborhood of 2100 deg. C. At lower temperatures the carbide regresses to its constituents. This latter phenomenon takes place rapidly at 1600 deg. C. and is retarded greatly in the vicinity of 900 deg. C.

Similar tests as were run on nickel carbide were made on copper carbide. Copper heated with sugar carbon at very high temperatures gave a carbide which was investigated. It would seem that at high temperatures a carbide is formed endothermically which rapidly dissociates into its constituents at 1600 deg. C. The decomposition velocity then decreases as the temperature decreases.

Recent Metallurgical and Chemical Patents

Oxygen and Hydrogen

Electrolytic Oxygen and Hydrogen Apparatus.—Improvements on an apparatus previously patented are the subject of another patent by R. J. J. MUELLER and E. G. ROWLANDS, of Sheboygan, Wisconsin (assigned to the Universal Oxygen Company, a Wisconsin corporation). The previous patent was abstracted in our issue of April 15, 1917, page 453. Among the improvements aimed at in the present patent are changes in the tank and diaphragm-frame construction. The wooden frame previously described is here replaced by a special member, which is also part of the tank itself and is insulated from both positive and negative poles. An improved method of suspending the diaphragm is described, also a closed bottom for each diaphragm and a trough-shaped member in the bottom of the diaphragm which serves as a receiver and retainer of scale and oxide dust dropping from the anode. Other improvements are changes in the anodes and in the bottom of the tank, which is enlarged and provided with a trough-shaped lining to cut off all electric action or flow of current from the bottom of the tank to the anodes; improved means for flushing or cleaning out the tank; means for inspection of the interior of the tank during operation; improved hermetic sealing-devices to prevent escape of gas to the open air and also of hydrogen to the oxygen chamber, or vice versa. 1,220,262, Mar. 27, 1917.)

Aluminium

Aluminium from Aluminium Carbide.—An electric furnace process of reducing aluminium carbide is patented by PAUL R. HERSHMAN, of Chicago, Ill. (Assigned to the Mineral Products Company of New York City.) Aluminium carbide mixed with 10 to 20 per cent by weight of aluminium oxide, chloride or sulphide is charged into a vertical electrical furnace which is designed to operate under pressure maintained by a safety valve, and in the presence of a suitable gas. A temperature of about 2100-2200 deg. C. and a pressure of 10-15 lbs. per sq. in. are used in the reduction. An oxide, chloride or sulphide of another metal may be added. In this case the proportion should be such that the eutectic alloy of aluminium and the other metal is formed. Thus with copper the alloy would be figured on, which would contain 94.2 per cent of aluminium and 5.8 per cent of copper. (1,220,843, Mar. 27, 1917.)

Furnace Construction

Combined Fuel and Electrically Heated Refining Furnace.—A refining furnace heated by both fuel gas and electricity is patented by ALOIS HELFENSTEIN, of Vienna, Austria-Hungary. In order to overcome the necessity for inserting electrodes each time the electrical heating is to be used, a long horizontal tubular furnace is used, with a metal bath which is shallow relative to the diameter of the furnace. An end view and longitudinal view of this furnace are shown in Fig. 1. The furnace is charged through openings 2 with fluid or cold charge and additional substances and receives the heating gas for carrying out the normal Martin process through the generator 3. In the bottom of the furnace the tube has inserted poles 4 through which the current from the dynamo engine or from a division of a transformer secondary current circuit can be transmitted at any time to the bath 5. The poles consist of first-class conductors, are water cooled and inserted so that they come into direct contact with the metal bath, and are connected outside the furnace with the source of current, but notwithstanding their arrangement are situated outside the fuel heating zone, and are thus not exposed to

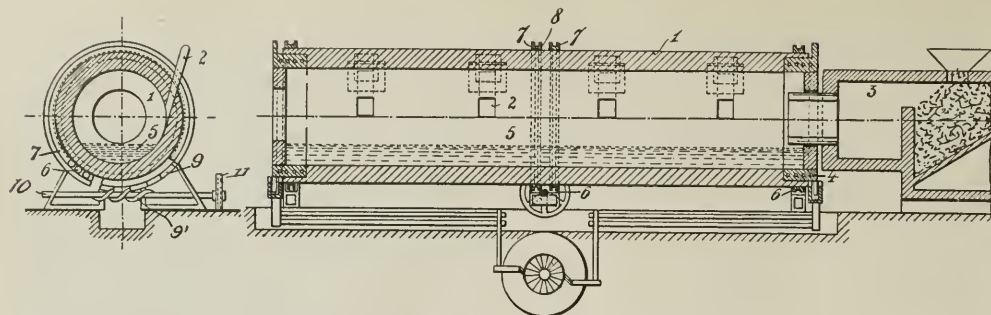


FIG. 1—FUEL AND ELECTRICALLY HEATED REFINING FURNACE

the high temperature. The tubular furnace is seated on rollers 6 and can be swung and rotated around its axis by a driving mechanism. (1,220,111, Mar. 20, 1917.)

Method of Making Furnace Hearths.—A method of making furnace hearths adapted to electric furnaces of the Heroult type and also to open-hearth or other metallurgical furnaces is patented by JAMES H. GRAY, of New York City. In the ordinary method of making hearths in electric furnaces a complete bottom of magnesia with a tar binder is rammed in cold and then fritted in place by placing a layer of coke on the bottom and passing current through by lowering the top electrodes. The fritting only penetrates for a few inches, leaving the lower part of the bottom still in the granular condition. In this condition the hearth is easily destroyed when the fritted surface breaks through. In the present patent it is proposed to introduce the bottom material in a molten or semi-molten condition, taking advantage of the fact that magnesia and similar materials are fairly good conductors of electricity at high temperatures. The procedure in making a hearth of magnesia or calcined magnesite in a Heroult furnace is given as follows:

"I first place a layer of magnesia bricks on the bottom of the shell of the furnace and then place a layer of granular magnesia one or two inches thick on the bricks. I then heat the furnace and the magnesia to such a temperature that the latter becomes a good conductor of electricity. This may be done in any one of several ways. For example, a flame furnished by fuel oil may be introduced into the furnace, or a bed of coke may be laid on the magnesia and the electric current passed through the coke from the electrodes in the manner above described to heat the same to incandescence, or lengths of electrodes may be laid on the bottom and the regular electrodes lowered to strike arcs therewith and to pass an incandescing current through these special lengths. Any one of these methods will bring the main electrodes to a white heat and will furnish sufficient heat in the furnace to bring the magnesia to a temperature at which it becomes a sufficiently good conductor of electricity. When this temperature is reached the electrodes are lowered to the bottom of the furnace (removing any coke or similar material which may have been introduced for the initial heating) and arcs are struck between the electrodes and the now conductive magnesia. The arcs and the current passing through the magnesia increase its temperature until it becomes molten or semi-molten or pasty. When this condition has been obtained more magnesia in granular form is introduced about the electrodes and this in turn becomes conductive as it receives heat both from the electric arcs and from the heated walls and atmosphere of the furnace. As the material banked about the electrodes becomes conductive the electrodes are gradually raised so as to maintain the necessary resistance at the arcs for the desired number of amperes of current to flow through the electrodes, the raising of the electrodes being accomplished either by hand or by automatic regulators such as are now generally employed for regulating the height of electrodes in such furnaces. The hearth is thus built up to the desired depth and shape in a sound and reliable monolith, by throwing in new material progressively at such points as may need building up."

One of the chief features of the method is the comparatively short time required. It is stated that for an open-hearth only 12 hours is required as compared with one to two weeks by older methods. (1,220,839, Mar. 27, 1917.)

Blast Furnace

Preheating Blast-Furnace Gases.—OTTO OESTERLEN, of Zweibrücken, Germany, patents a process of preheating blast furnace gases before dry cleaning, in which part of the gases are withdrawn, burned in a furnace and used to heat a preheater through which the gases pass. The part of the gases withdrawn for burning may be taken before the gases have passed through the preheater or afterwards. The gases after passing through the preheaters are filtered and an auxiliary preheater may also be used after filtering the gases. It is claimed that this method is more economical than preheating with steam, and the preheaters can be kept smaller on account of the high initial heat contained in the burnt gases. (1,219,852, Mar. 20, 1917.)

Sulphuric Acid

Manufacture of Sulphuric Acid.—Improvement in the manufacture of sulphuric acid by subjecting the gas at various points in the process to an electric discharge is the subject of a patent of WILLIAM J. KEE, Jr., of Kansas City, Kan., and UTLEY WEDGE, of Ardmore, Pa. The gas leaving the Glover tower, consisting of a mixture of sulphur dioxide, oxygen, nitrogen and nitrous gases, is passed through a flue or chamber in which an electric discharge is maintained. This causes a combination of nitrogen and oxygen, the conversion of low oxides of nitrogen to higher oxides of nitrogen, and the formation of ozone. Sulphur dioxide is oxidized to sulphur trioxide by both the ozone and the high oxides of nitrogen. As a result of these reactions the formation of H_2SO_4 in the presence of steam is more rapidly effected than in the ordinary process, and the consumption of nitric acid or nitrate of soda used is much reduced. The electric discharge may take place at other points, i. e., the gas coming from pyrites or sulphur burners could be immediately subjected to the electrical discharge, but the conditions here would not be so favorable on account of the high temperature causing dissociation of the ozone and higher nitrogen oxides. The treatment might take place inside the Glover tower or even in the Gay Lussac tower. (1,220,752, Mar. 27, 1917.)

Bureau of Mines Station in Idaho.—The Bureau of Mines has entered into a co-operative agreement with the University of Idaho, whereby an ore-dressing experiment station is to be located at Moscow, Idaho.

Electric Steel Progress in England

The adoption of the electric furnace for steel melting by the Sheffield steel trade continues to make rapid progress and the new Greaves-Etchells type of furnace, built by T. H. Watson & Co. (of Sheffield), Ltd., has an increasing share in this activity.

Kayser Ellison & Company, Ltd., Carlisle Works, Sheffield, have placed an order for a 10-ton Greaves-Etchells furnace, in addition to the one of 30 cwt. ($1\frac{1}{2}$ ton) capacity, which it is expected will soon be running.

One furnace of the same type of 3 tons capacity has been ordered by J. H. Andrew & Company, Ltd., Toledo Works, Sheffield, and 30-cwt. ($1\frac{1}{2}$ tons) furnaces have also been ordered by Thomas Andrews & Company, Ltd., of Sheffield, and Accles & Pollock, Ltd., of Birmingham.

A small furnace of the Greaves-Etchells type at the works of Spear & Jackson, Ltd., Sheffield, has now made over 1050 heats of high-speed steel and the lining has only once been renewed. A further larger furnace of this type was successfully started for this firm in March; also a furnace at Samuel Osborn & Company, Ltd., Sheffield.

According to T. H. Watson & Company (of Sheffield), Ltd., the owners of this furnace design, a number of additional furnaces will be installed as soon as consent is given by the Ministry of Munitions. The number already at work or about to be installed exceeds twenty.

One of the chief claims made for the Greaves-Etchells furnace by its makers is that it can readily melt the whole of its charge in the shape of shell turnings, etc., while it is claimed that in other furnaces only a limited quantity of turnings can be used new raw materials, pig iron, etc. The best place for the erection of a Greaves-Etchells furnace is, therefore, wherever there is an accumulation of turnings or steel scrap and a supply of electric current.

Palladium-Gold Crucibles as Platinum Substitutes

The high price of platinum (at present over \$100 per ounce for the pure grade) due to the difficulty of obtaining it from Russia has given impetus to the search for platinum-bearing ore in our own country and to the search for platinum substitutes. Considerable research has been conducted on alloy substitutes, several patents have been granted and use has been made of research undertaken in previous years.

A Los Angeles, Cal., firm has recently brought out and is distributing through the large laboratory supply houses an alloy of gold and palladium called "Palau," which is claimed to be even more than a platinum substitute—namely in some respects an improvement on ordinary platinum. A laboratory crucible and cover made of this alloy were tested by the Bureau of Standards at Washington from whose report the following data are taken.

"In general appearance the ware had nearly the surface color of pure palladium and was quite similar to, but slightly darker than hammered platinum. The crucible was fairly rigid, being not so easily deformed as a pure platinum crucible and not so stiff as a crucible made of platinum with about 8 per cent to 10 per cent rhodium."

The specific gravity at 4 deg. C. was found to be 17.22 and the melting point 1370 deg. C. The electromotive force against pure platinum at 960 deg. C. was 8.5 millivolts and at 860 deg. C. was 7.2 millivolts.

To compare with previous observations on platinum crucibles the heating and treatment with dilute acid were carried out as follows:

The loss in weight of the crucible due to heating was determined in a furnace free from metal vapors such as described in Bureau of Standards Scientific Paper No. 254.

This crucible was heated at 1200 deg. C. for two periods of four hours each and weighed before and after each heating. The weighings to determine the loss due to heating were followed by treatments for five minutes with boiling hydrochloric acid (1HCl to $4\text{H}_2\text{O}$) and the loss in weight due to the acid treatments was determined. The solutions obtained from this crucible contained less than 0.01 mg. of iron as Fe_2O_3 , determined by oxidizing the solution with bromine water, precipitating as hydroxide, filtering, igniting and weighing.

The summary of the Bureau of Standards is as follows:

"These tests indicate that the 'Palau' crucible, as far as resistance to loss on heating to 1200 deg. C. is superior to platinum containing about 2.4 per cent iridium, and somewhat inferior to platinum containing about 0.6 per cent iridium. The comparative freedom from iron is an improvement over most platinum ware now in use. It compares favorably with platinum in resistance to hydrochloric, nitric, hydrofluoric and sulphuric acids, ferric chloride and sodium hydroxide solutions and fused sodium carbonate. The 'Palau' crucible is not as suitable for potassium pyrosulphate fusions as platinum. For fusions with sodium carbonate and sodium nitrate the 'Palau' crucible is less attacked than platinum, but both wares are very seriously attacked under the conditions of our test, the fusion mixture containing no oxidizable material.

"The solubility of platinum is recognized and its elimination is provided for in exact methods of analysis. With the 'Palau' ware two metals, namely gold and palladium, may pass into solution, requiring somewhat different treatment for their elimination."

An interesting fact stated by the makers is that the ware will not wet; that the meniscus is downward as in the case of mercury.

Hydraulic Asbestos Press

The forming of fireproof shingles from an asbestos mixture can be accomplished by the use of a hydraulic press. The hydraulic press illustrated by Fig. 1 was originally designed for this purpose, but is also adaptable for other similar forming operations. It is a new design made by The Hydraulic Press Manufacturing Company, Mount Gilead, Ohio. The press was built for Japanese export trade, and will be used for forming asbestos shingles 42 in. square. The asbestos after being thoroughly mixed with other ingredients is formed into layers and placed upon drainage plates. Each plate consists of a steel plate, a sheet of woven wire and a sheet of duck cloth. A number of these plates with a layer of the mixed material to be pressed on each are stacked upon a steel truck which is then run into the press to receive the pressure for the purpose of extracting the excess moisture and to form each layer to a uniform thickness. The ingredients are also thus pressed into a solid mass. The formed slabs can be used in their original size, 42 in. square, or may be sawed into smaller pieces.

All of the operations of this press are controlled by one 2-in. four-way poppet operating valve. The press has two small push cylinders which return the main pressure ram after the pressing operation has been completed. These are mounted upon the base of the press

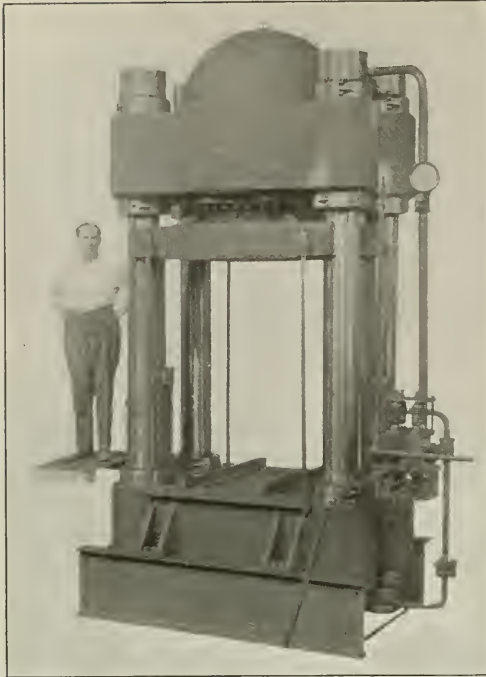


FIG. 1—42-IN. X 42-IN. X 6-IN. X 18-IN. RUN, 1500-TON
INVERTED ASBESTOS SHINGLE PRESS

between the strain rods. The push rams have a diameter of 5 in. and a run slightly greater than that of the main pressure ram.

The track running through the press is not attached to the base of the press, but is mounted on a frame which is supported from above by four rods working through lugs cast on the platen. These rods have lock nuts on their upper ends by which the rods are adjusted to support the track at its proper level. When the platen is at its highest point, the track is lifted a short distance from the pressure bed. As the platen travels downward, the track is lowered upon the pressure bed and the platen continues to travel over the rods which pass through the bearings in the platen lugs.

The wheels of the truck are so mounted that the bottom of the truck is slightly below the bottom of the track. When the platen starts down, it lowers the four supporting rods with the track while the truck bottom takes a bearing upon the press base, the wheels being released of all strain during the pressing operation. When the platen is returned, it again lifts the truck from the press base by raising the press track under the wheels and level with the track on the floor so that the truck can be run out of the press.

The strain rods are made of heat-treated forged steel and are machined to a diameter of 9 in. The heads of the strain rods are forged on. The heads take a bearing against split steel collars. The strain rod lugs on the cylinder and press base being bored, a perfect alignment is obtained through screwed strain rod collars.

Government Armor Plate Plant for West Virginia.—Secretary of the Navy Daniels recently announced that Charleston, W. Va., was the Government's choice as a site for its \$11,000,000 armor plate and projectile plant.

An Automatic Pressure Regulator for Pulpwood Grinders

Mechanical wood pulp is made by grinding logs to fibre by means of a revolving grindstone. The logs are placed in cylinders, called pockets, and are forced against the stone by a hydraulic pressure.

During the process there is a constant variation of the total pressure on the stone, because the pressure will change when a pocket is opened to insert a new log and while the face of the new log is being ground down to fit the contour of the stone. This variation in pressure is objectionable for two reasons. It causes, in the first place, a variation in the quality and the quantity of the product, and, secondly, a variation in the power required to drive the stone. This second objection is of special importance when motor drive with central station current is used, because it causes numerous peak loads considerably above the average load and the rates for current are generally based on the maximum, and not the average, demand. Since a pulp wood grinder requires a good deal of power, the difference between the power paid for and that actually used for useful work may represent a considerable sum.

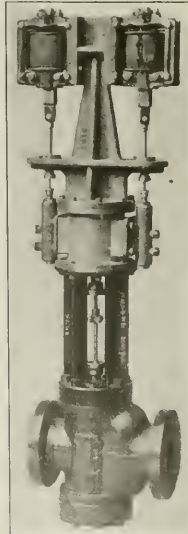
In order to insure a uniform pulp, increase the production and permit the grinder motor to operate at a load factor of practically 100 per cent, the Westinghouse Electric & Mfg. Co. has devised the regulator, shown in the illustration, which automatically varies the hydraulic pressure on the logs so that the load on the motor remains constant.

The action of the regulator is controlled by two solenoid magnets, which control the admission of the hydraulic pressure to the grinder cylinders containing the logs. When one of the solenoids is energized, pressure is admitted behind the pistons in the cylinders, thus increasing the pressure of the logs on the stone; when the other solenoid is energized, the pressure is admitted in front of the pistons, thus decreasing the pressure; when neither solenoid is energized the hydraulic valves are closed and the existing pressure is held.

The solenoids themselves are controlled by a set of relays, which receive current from a series transformer in the main motor circuit. The relays have two sets of contacts, each of which energizes one of the solenoids in the regulator. When the current taken by the motor exceeds a predetermined amount, one set of relay contacts is closed and as a result the pressure on the grindstone is decreased; while a decrease of current in the motor circuit increases the pressure on the stone. With normal current there is no variation in the pressure.

The results obtained by using this regulator are very marked. The power consumed by the grinder remains practically uniform at all times; a decided increase in production takes place; and the amount of shives, splinters and short fibers produced is reduced.

The regulator can be installed without alterations in the construction of the grinder and without interfering with



GENERAL VIEW OF
PRESSURE REGULATOR

production. It is designed to be foolproof and its adjustments cannot be changed by the grinder operators. Whenever necessary it can be cut out of service.

An Interesting Application of Portable Elevators

The installation of an overhead motor is not an easy task by the ordinary method with scaffolding, special heavy platforms, blocks and falls, etc. It is worthy of note that this and similar lines of work, such as fixing pulleys, installing shafting, etc., can be done by portable elevators which were designed primarily for piling barrels, boxes, etc. It is claimed by a manufacturer of these revolving portable elevators that from four to six motors can be installed in this manner in the time formerly required for one.

In the accompanying illustration is shown a portable elevator called the "revolvator," made by the N. Y. Revolving Portable Elevator Co., Jersey City, N. J.

It consists essentially of two uprights or elevator guides, an elevating platform and a revolving base which can swing around on its ball-bearing center like a turntable. The unit is mounted on strong truck wheels and is equipped with a floor lock. A motor or other



MOTOR RAISED IN PLACE BY ELEVATOR

article to be raised is placed on the revolving platform when down and by means of a crank and gears the platform is raised to the level desired. In elevating, the load is sustained independently of the crank, for a ratchet is provided with a special patented pawl which sustains the load at every point, eliminating all possibility of the platform being accidentally dropped.

Two sets of gears are provided, one for high speed and one for low. Loads up to 800 pounds can be raised on the high gear and heavier loads by the low gear. The machines are built from 6 to 20 feet in height. All machines 7 feet and larger have the frame hinged so that the top section may be folded over for the machine to pass through doorways. Special machines are built for lifting loads up to 2500 pounds, the standard revolvator being built in two sizes, one for loads up to 800 pounds and the other for loads up to 1800 pounds.

An Instrument for Indicating Jig Performance

A simple, but effective little instrument for indicating the performance of a jig has been designed and patented by W. F. Elwood, of Greensburg, Pa. The instrument consists simply of a cylinder, with a plunger having a needle on same, the needle moving on a scale as shown in Fig. 1. In Fig. 2, the jigometer is shown bolted to the screen of a coal jig, for which purpose it has been mainly used, although it would seem possible to apply it to jigs working on ores.

With every stroke of the jig plunger F , the needle M of the jigometer moves up and down accordingly.

Accumulation of refuse in the reservoir *K*, clogging of the gate at *C*, retarded pulsation of the plunger *F*, lack of water feed through *I* or lack of coal feed from *L* are all indicated by the position and performance of the needle *M* and can be immediately relieved. The jigometer is standardized for each particular jig on which it is intended to operate.

It is not necessary for the washerman to run his arm down into the dirty, black water in order to judge what is going on within the jig, but a glance at the needle of the jigometer tells him everything he needs to know in order to produce results.

It is claimed that this instrument solves the most perplexing phase of coal washing in that it positively registers the maximum and minimum bed required for the highest efficiency of the jigs; the maximum amount of refuse that may be permitted to collect in the reservoir



FIG. 1—GENERAL
VIEW OF JIG-
OMETER

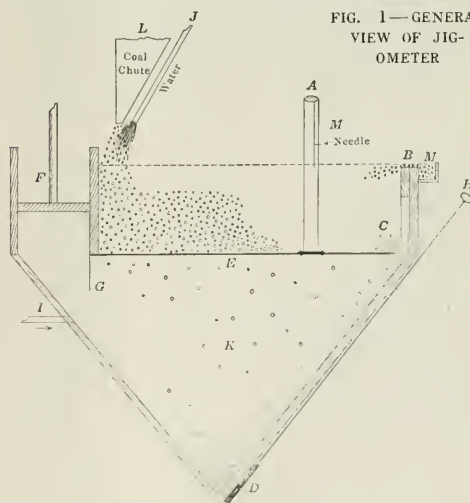


FIG. 2—JIGOMETER ATTACHED TO COAL JIG

below the screen before flushing the jigs, the depth to which the jigs should be flushed; the position of the water, the clearing ability of the screens and the efficiency of the jig plungers.

Metallurgical Fellowships at University of Utah

In the Department of Metallurgical Research of the State School of Mines, University of Utah, there have been established a number of research fellowships in metallurgy, having an annual value of \$720. These fellowships are open to college graduates who have had a good training in chemistry and metallurgy, and applications for them will be received up to May 15, 1917. Applicants should send a copy of their records from the registrar's office of the college where they have been, or soon will be graduated, and the names and addresses of at least three references who know their character, ability and attainments to Joseph F. Merrill, Director Utah State School of Mines, Salt Lake City.

By an agreement with the United States Bureau of Mines, the work of the metallurgical research department is under the direction of metallurgists of the Bureau, assigned to duty at the University. Mr. A. E. Wells, metallurgist, is in charge of the work, assisted by other members of the metallurgical staff as follows: Mr. O. C. Ralston, metallurgist, Mr. J. C. Morgan, chemist, Dr. F. B. Laney, microscopist, and Mr. R. E. Head, metallurgical assistant.

Due to the fact that Salt Lake City and vicinity is one of the chief non-ferrous metallurgical centers of the United States, and that the work taken up is of practical nature, that is, has to do with the solution of definite practical problems, the University believes that these fellowships offer a splendid opportunity to young men intending to enter the metallurgical profession, to thoroughly familiarize themselves with up-to-date metallurgical practice, especially in the treatment of non-ferrous ores, and to become proficient in the adaptation of those processes which may be in line with the investigation carried on by them in connection with their work.

During the fiscal year 1916-1917 the following problems have engaged those holding fellowships:

A study of flotation processes in order to determine their applicability to the treatment of ores which are not at present treated by such processes, and especially the low grade oxidized ores of lead and of zinc.

A comparison of various flotation oils and the testing and preparation of new and more effective oils.

The hydrometallurgical treatment of low grade and complex ores of lead.

The use of salt in the igneous concentration of low grade lead ores from desert localities.

The removal of iron from complex sulphides of zinc and iron.

The preparation of pure solutions from oxidized ores of zinc.

The chemical precipitation of solutions of zinc.

Destructive distillation of some of the hydrocarbons of Utah, such as gilsonite, elaterite, tabbyite, etc.

Holders of these fellowships will be subject to the rules governing employees of the United States Bureau of Mines and will report for duty for twelve months beginning July 1, 1917. They must also register as students in the University of Utah and become candidates for the degree of Master of Science in Metallurgy (unless this or an equivalent degree has been previously earned). Their class work will be directed by the heads of the departments of instruction, but the greater portion of their time will be spent in laboratory work, directed by metallurgists of the Bureau of Mines.

Accurate Determination of the Critical Point During Annealing

It is a well known fact that steels begin to lose their magnetism when heated to the lower transformation point and that they are non-magnetic when the transformation range has been passed. Hence they lose their magnetism over a range of temperature, varying from nothing to over 100 deg. Fahr., depending on the amount of carbon in the steel and upon the other constituents.

It is also well established that it is undesirable in hardening to heat much above the highest transformation point, Ac₁, Ac₂, or Ac₃, as the case may be. The use of a horseshoe magnet was recommended in some of the older books as a valuable aid in determining the proper temperature. This necessitated taking the piece from the furnace, however or resulted in careless work and such a method is not practical where any amount of work is done.

It has recently been more and more recognized that the old well known property of loss of magnetism should be valuable in determining the critical point and thus in controlling hardening of steels, both as a method to be used alone and also in conjunction with pyrometers. For all ordinary purposes, steels with 0.35 carbon and upwards will be heated sufficiently high when they become non-magnetic. For steels with less carbon than this, which lose their magnetism at Ac, it is easy to judge by the eye when they are heated to the Ac₁ point.

A very practical and inexpensive device has recently been developed and placed on the market for utilizing the magnetic property of steels by the Slocum, Avram and Slocum Laboratories, 531 W. Twenty-first Street, New York. It consists of a specially designed magnet, condensed in size, properly suspended upon a brass arm, and carefully balanced to allow of considerable sensitivity. The brass arm on which the magnet is balanced has interchangeable extensions, enabling the operator to apply the tool quickly and readily to furnaces of the smallest or largest type, or to an open forge. The simplicity of the apparatus and its freedom from anything which can get out of order would make it seem valuable for medium sized and smaller shops where extensive pyrometer installations and metallographic apparatus are not used, and also as a valuable accessory apparatus in any hardening plant, as pyrometers are not infallible and the magnet does away with the necessity of repeated laboratory tests to find the proper hardening temperature.

Personal

Mr. Edward M. Brown, one of the superintendents of the A. M. Byers Company, Columbia, Pa., has resigned, to take a position with Edward T. Edwards as assistant manager of the East End and Union Street rolling mills, operated in Columbia by Mr. Edwards. Mr. Brown has been connected with Columbia iron mills for twelve years.

Dr. John C. Hebden, vice-president and general manager of the Federal Dyestuff and Chemical Company, of Kingsport, Tenn., delivered an address before the Providence (R. I.) Engineering Society on Friday, April 20, on "Recent Advances in the Dyestuff Industry."

Messrs. C. W. Hunt, metallurgist and chemist; W. H. Goetz, mining and civil engineer, and L. F. Wolfinger, electrical and mechanical engineer, announce the opening of their offices at 803 Baker-Detwiler Building, Los Angeles, under the name of The Consolidated Engineers.

Mr. Francis S. Schimerka, who for the last four years has been in charge of leaching operations at the

Shannon Copper Company, Clifton, Arizona, has resigned his position.

Mr. J. Arthur Singmaster of the New Jersey Zinc Company, Palmerton, Pa., has been appointed general technical manager of the company, and will be located at the New York office of the company.

Mr. A. M. Snyder, mining engineer, metallurgist and specialist in flotation mills, has reopened his offices at 218-219 Security Building, Los Angeles.

Mr. C. E. Thies has severed his connection with Eimer & Amend and is now with the Palo Co., 90 Maiden Lane, New York City.

Mr. G. P. Uppington has been appointed district manager of the recently opened New York office at 90 West Street, of the Braemar Air Conditioning Corporation, of Philadelphia, Pa.

Mr. Bruce I. Whiting, formerly connected with the Snyder Electric Furnace Company, of Chicago, is now with C. W. Leavitt & Co., 30 Church Street, New York, in charge of sales of the Girod electric furnace, for which this company is the American agent.

Mr. R. T. Will has resigned his position as general superintendent and chemical engineer of the General Coal Products Company, of Pittsburgh, Pa., to establish offices and laboratories at Rochester, N. Y., for general testing and consultation in industrial and chemical engineering, under the name of The Will Corporation. The new laboratories are located at 262 East Avenue.

Book Reviews

Radio-Activity. By F. C. Venable. Handy size, 50 pages, \$0.50. New York: D. C. Heath & Co.

A fascinating, finely written little book that can be read through in an hour. It gives the net results and conclusions of the last twenty years' study of radio-activity, the structure of the atom, and the constitution of matter.

* * *

Microscopic Examination of Steel. By Henry Fay, Ph.D., D.Sc. Octavo (15 x 22 cm.), 18 pages, 56 photomicrographs. Price, \$1.25. New York: John Wiley & Sons, Inc.

A reprint of material originally published by the U. S. Ordnance Department, representing the results of investigations at the Watertown Arsenal. The text is very brief and to the point, and the photographs are very good. It is a mere outline of metallographic methods illustrated by typical examples, and is intended particularly to help learners or workers in metallography who need some precise advice and instruction in the interpretation of results. It is admirably suited to serve this end, within the limits imposed.

We heartily commend and agree with the author's comment that "there is a tendency to over-rate the application of metallography. Used in connection with the physical tests and chemical analyses it furnishes valuable supplementary data."

* * *

Awakening of Business. By Edward N. Hurley, Chairman of the Federal Trade Commission. Duodecimo (12 x 19 cm.), 240 pages. Price, \$2.00 net. New York: Doubleday, Page & Co.

The distinguished economist here expresses in plain language the plain truths which he thinks American business men need to know and observe. It is intended not as a message of congratulation, but as one of warning. Its further intention is to inform them of Government activities in their behalf and bring them into closer harmony with the Government.

Parts of the book are elementary to the verge of inanity. It is difficult to imagine that any man

actually in business needs to be told the necessity for intelligent cost accounting, that "profit is the difference between cost and selling price," that depreciation must be properly allowed for, and a sinking fund provided for accidents or obsolescence of machinery. Such advice sounds like telling an engineer that he must not strain the material in a machine past its elastic limit, that he needs to apply a factor of safety to a construction; it seems like waste of ink and paper.

Other parts of the book, which utilize the special qualifications of the author to discuss the relations of Government to business, are valuable and illuminating. His discussions of Government regulation, trade associations, commercial education, foreign trade, and investment abroad are timely and thought-compelling, even though they may not always be completely convincing.

CURRENT MARKET REPORTS

The Iron and Steel Market

Consumers of steel products have continued to place contracts freely, despite the fact that delivery promises have become still more uncertain. There has been little buying of steel products for specific jobs, the great bulk of the business placed being in the form of ordinary contracts, which merely give the buyer a place on order books, orders to be filled in rotation. A very large business has been done in sheets and tin plates, the mills having opened books for the second half of the year early in April, and the total steel business done in the month will easily exceed the March total. The Steel Corporation's unfilled obligations, which increased by 134,947 tons in March, may show an increase of more than 500,000 tons for April.

In the last analysis, however, the steel business done is no accurate criterion of the steel trade's prospects, say for the next twelvemonth. There is reason to surmise that buyers of steel have acted upon their appraisal of prospects for steel supplies in future, rather than upon an appraisal of what their respective lines of activity will really require. The steel mills, as a rule, are filled with orders which cannot be completed in an average of less than 10 or 12 months. If the buyers of steel know for a certainty what quantities of their manufactured goods the public will be buying from them nine months hence they are certainly very wise. On the other hand it has required no great degree of courage to act upon the common belief that as war requires steel the material is going to be scarce for the duration of the war.

PRODUCTION HEAVIER

Transportation conditions as regards the iron and steel industry have improved further. Car supplies in the Connellsville coke region have become practically adequate and the blast furnaces are producing pig iron substantially at capacity, at a rate doubtless exceeding 40,000,000 tons a year. The steel mills are operating full and are shipping their entire product, while they have cleaned up practically all the accumulations of the winter. Some fears are entertained that with the opening of the season of lake navigation, with a heavy movement of coal to Lake Erie ports and a still heavier movement of ore therefrom a fresh congestion will be developed, but on the other hand there will soon be available the corrective influence of unit operation of the entire railway system of the country under the auspices of the Council of National Defense.

STEEL FOR WAR

For the 1917 naval program a trifle over 400,000 tons of steel has been secured by the Government, at 2.90c.

for the plates and 2.50c. for the relatively small tonnage of bars and plain shapes, these being the prices that ruled for several months prior to the advance of Aug. 1, 1916. About 75,000 tons of fitted structural work, for navy yard extensions, is included at a commensurate price. The "saving" to the Government is variously estimated at \$10,000,000 to \$18,000,000, depending upon whether comparison is made with premium prices now ruling for prompt deliveries, or with prices ruling for "delivery at mill convenience." It appears that the United States Steel Corporation, which makes about one-half the country's production, underwrote the whole business, while independent producers are now privileged to step up and undertake their respective shares.

Considerable tonnages of steel are involved in orders now being placed or about to be placed, for various camp paraphernalia, tent pins, tent stoves, camp ranges, barracks, etc. Orders for cables and wire rods for submarine defense have doubtless run into thousands of tons. Some of these orders preceded the declaration of war.

Until the item of shells is reached, the government's steel requirements can hardly total over a million tons for a twelvemonth. In shells, however, there is hardly any limit. When the matter is reached the Government will probably buy steel, in large rolled rounds and forging billets, and farm the steel out to shell manufacturers. The Government will probably itself buy the steel the European Allies may require. Price concessions on all this steel are expected.

The French Government has placed two rail orders, for 20,000 tons each, while Italy has bought 15,000 tons. A press dispatch from Petrograd is to the effect that Russia is about to buy 40,000 freight cars and 2000 locomotives, for delivery in July, 1918.

In the past few months the European Allies have greatly decreased their demands upon the United States for steel, having increased their own productive capacity, and very large business would have to be done, under the proposed plan of financing by the Government, to bring the flow of steel to the Allies up to the former rate. On account of the scarcity of bottoms exports of steel to neutral countries will undoubtedly be materially less than they were last year. All things considered, it does not seem probable that the supply of steel for ordinary domestic consumption will be greatly reduced. It cannot be regarded as probable, but it is conceivable, that if the war lasts another twelvemonth steel will be more plentiful than now.

SCARCITY OF PIG IRON

There has been a wild scramble for pig iron in some districts, whereby the furnaces have become largely sold up for the first half of 1918, while furnaces in other districts still have tonnage available for the second half of this year. In all districts prompt iron is scarce, and prices have been advancing, though scarcely at as great a rate in the second half of April as in the first half. Prices at Birmingham range from \$35 to \$37. In the valley market Bessemer is \$42 and basic, foundry and malleable \$40, with occasional premiums for prompt shipment. The scarcity of pig iron represents the working out of a theory long entertained, that as steel making capacity has been increasing much more rapidly than blast furnace capacity the supply of pig iron would eventually prove inadequate. Steel billets, however, manage to maintain at least their former spread above pig iron, being \$75 to \$80 and hard to buy at that. Rods are commanding \$85 to \$90.

Finished steel prices are generally unchanged in the fortnight, except for advances in sheets, wire products and railroad spikes. Premiums for early deliveries,

however, have increased. Early delivery plates have brought various prices from 6c. to 9c.

As noted in last report, the American Sheet & Tin Plate Company opened its books for second half deliveries at \$7.50 for tin plate, 5c. for blue annealed sheets, 5.50c. for black sheets and 7c. for galvanized sheets, all in Bessemer, with a quarter-cent advance for open-hearth. Soon the company became sold up for the half-year and withdrew from the market. Independents then rapidly advanced their prices, the market being now quotable at 6c. to 6.75c. for blue annealed, 6.50c. to 7.50c. for black and 8c. to 9c. for galvanized. Independent tin plate mills closed with a few favored customers at \$7.50, but in general have been booking their trade at \$8, for Bessemer or open-hearth, while buyers not regular customers have paid \$8.50.

Wire prices have advanced \$6 a ton to 3.45c. for plain wire, 4.15c. for galvanized wire, \$3.50 for wire nails, 3.65c. for painted barb wire and 4.35c. for galvanized barb wire.

Bars, plates and shapes are unchanged for delivery at mill convenience at 4.50c. for plates, 3.60c. for shapes and 3.35c. for bars, but in plates and shapes these prices are largely nominal.

The Non-Ferrous Metal Market

Monday, April 23.—No spectacular changes have occurred in the non-ferrous metal market during the past two weeks. Copper has declined slightly but no great weakness has developed. Tin is strong and has advanced. Lead is likewise strong and remains scarce. Spelter continues weak. Antimony has declined slightly while silver has advanced steadily.

Copper.—The situation in copper is very interesting. There have been no large offers by the large producers which would tend to depress the market, but resale lots by dealers coupled with a waiting policy on the part of consumers have lowered the market. Electrolytic has declined from 33.00 cents on the 12th to 31.50 on the 20th. Lake has declined from 33.50 on the 12th to 32.00 on the 20th. Brass exports in February continued very heavy, totaling in value over \$30,000,000, which is nearly three times the value for the same period last year.

Tin.—The chief topic of interest centered in the import duty of 10 cents, which it was rumored would be placed on tin. In view of the fact that tin enters so largely into the making of cans and other tin plate articles, it is unlikely that the Government will take any action in this respect at this time. The consuming demand has not increased to any extent, and this probably accounts for the small advance in face of the small arrivals of 1800 tons up to the 19th and the advance in the London market. Spot Straits is quoted at 55.75 at present, with Banca tin offered at about 1 cent under this price.

Spelter.—This market is experiencing a very dull period. Prompt spelter has declined from 10.00 cents on the 12th to 9.30 on the 20th. Consumers seem to be holding off waiting action by the Government, whose business is expected to be in the intermediate and high grades. Ore prices are high and this reacts to the detriment of the smelters.

Lead.—Supplies of lead continue scarce both on spot and futures, and independents asking prices are somewhat higher, being 9.75 cents for prompt shipment. The Trust price of lead remains at 9.00 cents.

Other Metals.—Antimony continues high in price, but has declined from 35.50 to 34.00 cents. Aluminium is unchanged at 60.00 cents. Magnesium has dropped to \$2.50 to \$3.00 with a larger production. Quicksilver

is quoted at \$113.00 per flask. Cadmium is \$1.50, cobalt \$1.70. Pure platinum is \$105.00 per ounce. Silver is 74 $\frac{7}{8}$ ¢.

Chemical Market

Coal Tar Products.—The general tendency of items under this classification has been to a decidedly firmer basis throughout the past two weeks and there has been very important buying on the part of consumers, who are seemingly of the opinion that the markets are to go against them. Producers have the situation well in hand, and it is rumored that a general understanding has been reached by the most important factors in regard to future operations. It is understood that this will mean higher prices for all crudes which have been advancing slowly but surely the past month, and especially an improved condition in the market governing phenol, which has been the only weak spot in the coal tar situation the past quarter. All coal tar crudes are considered good "buys" at the present moment.

Benzol.—Spot supplies have been practically eliminated from the market, and for future deliveries sellers are not inclined to offer any appreciable quantities except for nearby deliveries to regular consuming trade. A new buyer finds difficulty in securing quotations.

Toluol.—The situation is a very firm one indeed. The Government has already purchased 2,500,000 lb. of T. N. T., unrefined, and opens bids April 24th for 1,030,000 lb. refined and 700,000 lb. unrefined. The first purchase required approximately 100,000 gallons of toluol. These purchases are forerunners of regular requirements that are expected at comparatively short intervals from the government and can but reflect a firm situation in toluol. Excess profits will, of course, not be made on government business, but these supplies eliminated from the market will naturally result in a shortage of offerings for general industrial purposes.

Phenol.—Business continued disappointing and the anticipated demand for picric acid manufacture has not materialized. Apparently T. N. T. has supplanted picric acid as a popular explosive. However, in view of certain events the general opinion is that phenol will reach 50c. before the Fourth of July.

Aniline Oil.—Important business has passed for all nearby positions and prices are high and stocks extremely light. Some of the manufacturers who dropped out of the producing end some time ago as a result of low prices have again placed their plants in operation, but this increased output has not been as yet sufficiently large to take care of the greatly increased demand. The outlook for aniline oil appears quite bright after a depressing half-year.

Monochlorbenzol.—Manufacturers have caught up on their orders somewhat and contracts are now being made and offered at lower prices than have heretofore prevailed.

Beta Naphthol.—An important consuming demand has been noted from various technical sources and the position is somewhat improved, but poor quality offerings have had a tendency to keep price levels from advancing materially.

Benzidine.—There has been manufacturing difficulty reported, but the few producers are now selling about all the material they can offer.

Toluidines.—Practically all available capacity for producing *para* has been sold and manufacturers have been enabled to sell *ortho* at a low price because of the high price obtained for *para*. *Nitro toluols* have also been in urgent request. A producing source for *meta nitro para toluol* is reported, with the seller quoting \$7.50.

Schaeffer Salt and Bröner's Acid are now being offered from a domestic manufacturing source, with

prices quoted on the approximate basis of \$2.00 to \$2.25. It is also announced that supplies of *R acid* and *N acid* will shortly be available. The latter will probably be quoted in the neighborhood of \$5.00.

H acid (the amidonaphthol disulphonic acid 1:8:3:6).—The situation has not changed much since our last report on this interesting product except that one of the producers has gone into receivership. Aside from the dye manufacturers who make for their own use there is only one firm making regular deliveries. A large number of companies plan a production, none of which has so far materialized.

Heavy Chemicals.—Practically every item in this classification has been subject to important consuming inquiry, and where prices have shown a tendency to advance consumers have generally rushed to cover. Exceptions have been cyanides and bichromates which have eased off. *Nitrate of soda* has been subject to a spectacular advance. Prices have more than doubled the past month. The two domestic producers are sold out and Norwegian importations have ceased. At least three new domestic manufacturing factors will enter the market within the year. *Caustic soda* and *soda ash* have been very active and short interests have been covering. Nineteen-seventeen business is difficult to obtain and most producers are sold out for the best part of 1918. Three-year contracts are being turned down. Ordinarily a producer will take business for several years ahead. Indications point to continued firmness. *Bichromates* markets, subject nearly always to considerable manipulation, have gradually declined and business has been taken for export at the lowest figure that has prevailed for some little time. *Cyanides* are moving slowly and the position has been much easier as a result of the large offerings of Japanese material. *Chlorates* have also been rather neglected after an active year. The general market appears to be gradually adjusting itself to war time business and interesting developments are looked for.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET APRIL 21, 1917	
Acetic anhydride	lb. 1.50 — 1.75
Acetone Drums	lb. .27 — .27 $\frac{1}{2}$
Acid, acetic, 28 per cent.	lb. .04 $\frac{1}{2}$ — .05
Acetic, 56 per cent.	lb. .09 — .10
Acetic, glacial, 99 $\frac{1}{2}$ per cent carboys.	lb. .28 — .30
Boric, crystals	lb. 1.10 $\frac{1}{2}$ — .11
Citric, crystals	lb. .73 — .75
Hydrochloric, 18 deg.	lb. .01 $\frac{1}{4}$ — .01 $\frac{3}{8}$
Hydrochloric, 20 deg.	lb. .01 $\frac{1}{8}$ — .01 $\frac{1}{4}$
Hydrochloric, C. P. conc., 22 deg.	lb. .01 $\frac{1}{8}$ — .01 $\frac{1}{4}$
Hydrofluoric, 30 per cent, in barrels.	lb. .04 $\frac{1}{4}$ — .05
Lactic, 44 per cent.	lb. .11 — .12
Lactic, 22 per cent.	lb. .04 $\frac{1}{2}$ — .05
Nitric, 36 deg.	lb. .05 $\frac{1}{2}$ — .05 $\frac{1}{4}$
Nitric, 42 deg.	lb. .06 $\frac{1}{2}$ — .07
Oxalic, crystals	lb. .45 $\frac{1}{2}$ — .48
Phosphoric, 80 per cent.	lb. .33 — .37
Picric	lb. .70 — .75
Pyrogallol, resublimed	lb. 3.50 — 4.00
Sulphuric, 60 deg.	ton 29.00 — 30.00
Sulphuric, 66 deg.	ton 29.00 — 30.00
Sulphuric, oleum (Fuming), tank cars.	ton 38.00 — 40.00
Tannic, U. S. P. bulk.	lb. .45 — .50
Tartaric, crystals	lb. .83 — .85
Alcohol, grad., 188 proof.	gal. 3.03 — 3.05
Alcohol, wood, 95 per cent.	gal. 1.00 — 1.02
Alcohol, denatured, 180 proof.	gal. .70 — .72
Alum, ammonia lump.	lb. .04 — .04 $\frac{1}{2}$
Alum, chrome ammonium	lb. 1.17 $\frac{1}{2}$ — .20
Alum, chrome potassium	lb. .35 — .40
Alum, chrome sodium.	lb. .12 — .12 $\frac{1}{2}$
Alum, potash lump.	lb. .05 $\frac{1}{2}$ — .05 $\frac{3}{4}$
Aluminum Sulphate, technical.	lb. .01 $\frac{1}{2}$ — .02
Aluminum Sulphate, iron free.	lb. .03 — .03 $\frac{1}{4}$
Ammonia aqua, 26 deg. carboys.	lb. .05 $\frac{1}{4}$ — .06
Ammonium carbonate	lb. .12 — .13
Ammonium nitrate.	lb. .18 — .17
Ammonium sulphate domestic.	lb. .05 $\frac{1}{2}$ — .06
Amyl acetate	gal. 4.00 — 4.25
Arsenic, white	lb. .14 — .17
Arsenic, red	lb. .20 — .20
Barium chloride	ton 85.00 — 90.00
Barium sulphate (Hanc Fixe) powder.	lb. .01 — .04 $\frac{1}{2}$
Barium nitrate	lb. .10 $\frac{1}{2}$ — .11
Barium peroxide 70 per cent.	lb. .27 — .27 $\frac{1}{2}$
Bleaching powder, 35 per cent chlorine.	lb. .03 $\frac{1}{2}$ — .03 $\frac{3}{4}$
Borax, crystals, sacks.	lb. .07 $\frac{1}{2}$ — .08
Brimstone, crude	ton 45.00 — 50
Bromine, technical.	lb. .30 — .30
Calcium, acetate, crude.	lb. .03 — .03 $\frac{1}{2}$

Calcium carbide	ton	80.00	—	90.00
Calcium chloride, 70-75 per cent, fused, lump	ton	26.00	—	28.00
Calcium peroxide	lb.	1.80	—	1.90
Calcium phosphate	lb.	.30	—	.31
Calcium sulphate	lb.	.01	—	.02
Carbon bisulphide	lb.	.09	—	.10
Carbon tetrachloride, drums	lb.	.15	—	.16
Caustic potash, 82-92 per cent.	lb.	.75	—	.78
Caustic soda, 76 per cent.	100 lb.	4.75	—	4.85
Chloride, liquid	lb.	.15	—	.18
Cobalt oxide	lb.	.62	—	.64
Copperas	100 lb.	1.05	—	1.10
Copper carbonate	lb.	.33	—	.35
Copper cyanide	lb.	.75	—	.78
Copper sulphate, 99 per cent, large crystals	lb.	.09	—	.09½
Cream of tartar, crystals	lb.	.46½	—	.47
Epsom salt, bags	100 lb.	3.25	—	3.50
Formaldehyde, 40 per cent.	lb.	1.14½	—	1.15
Glauber's salt	100 lb.	1.52	—	1.54
Glycerine, bulk, C. P.	lb.	.56	—	.57
Iodine, resublimed	lb.	3.50	—	3.56
Iron oxide	lb.	.02	—	.08
Lead acetate, white, crystals	lb.	.14	—	.14½
Lead arsenate	lb.	.10	—	.11
Lead nitrate	lb.	.16½	—	.17
Litharge, American	lb.	.08	—	.19
Lithium carbonate	lb.	1.05	—	1.05
Manganese dioxide	lb.	.65	—	.65
Magnesium carbonate tech.	lb.	.24	—	.26
Nickel, salt, single	lb.	.14	—	1.41
Nickel, salt, double	lb.	.11	—	.12
Phosphorus, red	lb.	1.12	—	1.25
Phosphorus, yellow	lb.	1.05	—	1.10
Potassium bichromate	lb.	.34½	—	.35
Potassium bromide granular	lb.	1.00	—	1.05
Potassium carbonate calcined, 80-85 per cent.	lb.	.31	—	.35
Potassium chlorate, crystals	lb.	.58	—	.60
Potassium cyanide, 98-99 per cent.	lb.	1.35	—	1.40
Potassium iodide	lb.	2.90	—	2.92
Potassium muriate, 50-55 p. c., basis of 80 p. c.	ton	390.00	—	400.00
Potassium nitrate	lb.	.30	—	.32
Potassium permanganate	lb.	3.65	—	3.75
Potassium prussiate, red	lb.	2.50	—	2.70
Potassium sulphate, yellow	lb.	.92	—	.94
Potassium sulphate, 90-95 p. c., basis 90 p. c.	ton	310.00	—	325.00
Rochelle salts	lb.	.37½	—	.38½
Sal ammoniac, gray gran.	lb.	.11	—	.12
Sal ammoniac, white gran.	lb.	.17	—	.18
Salt soda	100 lb.	1.10	—	1.20
Salt cake	100 lb.	.90	—	1.00
Silver cyanide	oz.	.70	—	.70
Silver nitrate	oz.	.46½	—	.47
Soda ash, 58 per cent, light, flat	100 lb.	3.25	—	3.30
Soda ash, 58 per cent, dense, flat	100 lb.	3.60	—	3.65
Sodium acetate	lb.	.98½	—	.99
Sodium benzoate	lb.	7.00	—	7.25
Sodium bicarbonate, domestic	100 lb.	1.95	—	2.00
Sodium bicarbonate, English	lb.	.14½	—	.15
Sodium bichromate	lb.	.03½	—	.04
Sodium chlorate	lb.	.23½	—	.25
Sodium cyanide	lb.	.90	—	1.05
Sodium fluoride, commercial	lb.	.18½	—	.19
Sodium hyposulphite	lb.	.01½	—	.02
Sodium nitrate, refined	lb.	.05½	—	.05½
Sodium nitrite	lb.	.29	—	.31
Sodium peroxide	lb.	.50	—	.55
Sodium phosphates (trip)	lb.	.04½	—	.04½
Sodium prussiate, yellow	lb.	.30	—	.31
Sodium silicate, liquid—40 deg. Baume.	100 lb.	1.20	—	1.30
Sodium sulphide, 30 per cent, crystals	lb.	.03	—	.03½
Sodium sulphide, 60 per cent, fused	lb.	.05	—	.05
Sodium sulphite	lb.	.03½	—	.03½
Strontium nitrate	lb.	.28	—	.30
Sulphur chloride, drums	lb.	.11	—	.12
Sulphur, dioxide, liquid, in cylinders	lb.	.11½	—	.12
Sulphur, flowers, sublimed	100 lb.	3.20	—	3.30
Sulphur, roll	100 lb.	2.55	—	2.60
Sulphur, crude	ton	45.00	—	46.00
Tin bichloride, 50 deg.	lb.	1.14½	—	1.15
Tin oxide	lb.	.54	—	.56
Tungstic acid, basis 100 per cent.	lb.	1.40	—	1.50
Zinc carbonate	lb.	.26	—	.27
Zinc chloride	lb.	.15	—	.15½
Zinc cyanide	lb.	.50	—	.50
Zinc dust, 350 mesh	lb.	.19	—	.20
Zinc oxide, American process, XX	lb.	.12	—	.12½
Zinc sulphate	lb.	.06½	—	.07

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.58	—	.60
Benzol, 90 per cent.	gal.	.57	—	.59
Toluol, pure, water white	gal.	1.90	—	2.00
Xylol, pure, water white	gal.	.60	—	1.00
Solvent naphtha, water white	gal.	.17	—	.20
Solvent naphtha, crude, heavy	gal.	.13	—	.16
Creosote oil, 25 per cent.	gal.	.28	—	.30
Dip oil, 20 per cent.	gal.	.26	—	.26
Pitch, various grades	ton	8.00	—	20.00
Carbolic acid, crude, 95-97 per cent.	lb.	.90	—	.95
Carbolic acid, crude, 50 per cent.	lb.	.55	—	.60
Carbolic acid, crude, 25 per cent.	lb.	.30	—	.32
Cresol, U. S. P.	lb.	.20	—	.20

Intermediates, Etc.

Alpha naphthylamine	lb.	.90	—	1.05
Aniline oil	lb.	.28½	—	.30
Aniline salts	lb.	.32	—	.34
Anthracene, 80 per cent.	lb.	.10	—	.10
Benzoic acid	lb.	4.50	—	5.00
Benzenide, base	lb.	1.85	—	2.00
Benzenide, sulphate	lb.	1.60	—	1.65
Benzoic acid	lb.	7.00	—	7.50

Beta Naphthol, sublimed	lb.	.80	—	.85
Dichlor benzol	lb.	.23	—	.24
Dinitro chlorbenzol	lb.	.46	—	.48
Dimethylaniline	lb.	.57	—	.59
Diphenylamine	lb.	.85	—	.90
H-Acid	lb.	Nominal	—	Nominal
Metaphenylenediamine	lb.	1.60	—	1.65
Monochlorbenzol	lb.	.30	—	.32
Naphthalene, flake	lb.	.09½	—	.10
Naphthionic acid, crude	lb.	1.50	—	1.75
Nitro naphthalin	lb.	.50	—	.60
Ortho-amidophenol	lb.	1.20	—	1.30
Ortho-toluidine	lb.	5.00	—	5.50
Para-amidophenol base	lb.	1.20	—	1.25
Parantraniline	lb.	3.50	—	3.75
Paraphenylenediamine	lb.	2.25	—	2.50
Para toluidine	lb.	.42	—	.44
Phenol, U. S. P.	lb.	16.00	—	17.00
Resorcin, technical	lb.	.83	—	.85
Resorcin, pure	lb.	1.40	—	1.60
Salicylic acid	lb.	.32	—	.33
Sulphanilic acid	lb.	.33	—	.33
Toluidine	lb.	.65	—	.80
Toluidine-mixture	lb.	.65	—	.80

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbbl.	3.05	—	...
Corning, Ohio	bbbl.	2.33	—	...
Somerset, Ky.	bbbl.	2.18	—	...
Wooster, Ohio	bbbl.	2.05	—	...
Indiana	bbbl.	1.73	—	...
Illinois	bbbl.	1.57	—	...
Oklahoma and Kansas	bbbl.	1.70	—	...
Caddo, La., light	bbbl.	1.90	—	...
Corsicana, Tex., light	bbbl.	1.70	—	...
California	bbbl.	.73	—	.82

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.13½	—	.14
Cylinder, light	gal.	.21	—	.26
Cylinder, dark	gal.	.18	—	.19
Paraffine, high viscosity	gal.	.29½	—	.30
Paraffine, .903 sp. gr.	gal.	.21½	—	.22
Paraffine, .865 sp. gr.	gal.	.18½	—	.19

Flotation Oils

(Prices at New York)

Pine oil, steam distilled, sp. gr. 0.925-0.940	gal.	.52½	—	...
Pine oil, destructively distilled, sp. gr. 0.920-0.940	gal.	.48	—	...
Pine-tar oil, sp. gr. 1.025-1.035	gal.	.23	—	...
Pine-tar oil, double refined, sp. gr. 0.965-0.970	gal.	.32	—	...
Pine oil, light, sp. gr. 0.950, tank cars	gal.	.37	—	...
Pine oil, heavy, sp. gr. 0.925, tank cars	gal.	.26	—	...
Pine oil, light, sp. gr. 1.060-1.080	gal.	.49	—	...
Turpentine, crude, sp. gr. 0.980-1.000	gal.	.19	—	...
Hardwood oil, sp. gr. 0.960-0.990	gal.	.21	—	...
Hardwood oil, sp. gr. 1.06-1.08	gal.	.23	—	...

Vegetable and Other Oils

China wood oil	lb.	.14½	—	.15
Cottonseed oil, crude	gal.	1.00	—	...
Linseed oil, raw, cars	gal.	1.10	—	...
Peanut oil, crude	gal.	.15	—	...
Rosin oil, first run	gal.	.38	—	...
Rosin oil, fourth run	gal.	.67	—	...
Soya bean oil, Manchuria	lb.	.13½	—	...
Turpentine, spirits	gal.	.52	—	...

Miscellaneous Materials

Barytes, floated, white, foreign	ton	23.00	—	40.00
Barytes, floated, white, domestic	ton	28.00	—	32.00
Beeswax, white, pure	lb.	.52	—	...
Carnauba wax, highest grade	lb.	.51	—	...
Chalk, light, precipitated, English	lb.	.03	—	.06
Feldspar	ton	8.00	—	12.00
Fuller's earth, pure	100 lb.	.80	—	1.05
Ozokerite, crude, brown	lb.	.60	—	.70
Ozokerite, American	lb.	.35	—	.35
Red lead, dry, carloads	ton	10.00	—	10½
Rosin, 250 lb.	bbbl.	6.00	—	...
Soapstone	ton	10.00	—	12.50
Talc, American, white	ton	10.00	—	13.00
White lead, dry	lb.	.09½	—	...

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	Nominal	—	...
Chrome cement, Grecian	net ton	60.00	—	...
Clay brick 1st quality freclay	per 1000	45.00	—	...
Clay brick, second quality	per 1000	30.00	—	...
Magnesite, Grecian, dead burned	net ton	90.00	—	...
Magnesia brick, Grecian, 9x4½x2½	net ton	140.00	—	...
Silica brick	per 1000	45.00	—	...

Ferroalloys

Ferrocromium	lb.	Nominal	—	...
Ferromanganese, domestic, delivered	ton	400.00	—	425.00
Ferromanganese, English	ton	200.00	—	...
Ferromolybdenum, per lb. of Mo.	lb.	4.00	—	...
Ferrosilicon, 50 per cent, carloads, del. Pitts-	ton	200.00	—	225.00
Ferrosilicon, 50 per cent, carloads, del. Pitts-	ton	100.00	—	...
Ferrotungsten, 75-85 per cent, f.o.b. Pitts-	lb.	2.00	—	...
Ferrovandium, f.o.b. works	lb.	2.75	—	3.00

INDUSTRIAL

Financial, Construction and Manufacturers' News

Financial

New Companies

The Acme Dye and Chemical Co., Metuchen, N. J., has been incorporated with a capital of \$100,000 to manufacture chemicals and oils.

The Alumetol Co., Wilmington, Del., has been incorporated with a capital of \$600,000 to do a general mining, milling and refining business. The incorporators are H. R. Letter, N. P. Coffin, C. M. Egner, Wilmington, Del.

Anchor Sheet Glass Co., Del., has been incorporated with a capital of \$2,000,000 to manufacture sheet glass products of all kinds. The incorporators are D. H. Felner, A. A. Icanhour, C. W. Barnett, Clarksburg, W. Va.

The Arizona Superior Copper Company, Newark, N. J., has been incorporated with a capital of \$1,000,000. The incorporators are George H. Russell, Frank H. Van Winkle and Nelson R. Vanderhoff. The local agent is the New Jersey Corporation Agency, of 201 Washington Street.

A. H. Y. Color Chemical Company, Bridgeton, N. J., has been incorporated with a Delaware charter and capital of \$10,000 to operate a local plant. The incorporators are A. H. and B. R. Yedigly, Bridgeton, and William K. Harris, Woodbine, N. J.

Aryl Chemical Co., Brooklyn, N. Y., has been incorporated with a capital of \$5,000 to manufacture synthetic organic compounds. The incorporators are Jacob Jay, Wilhelm Greenberg, Michael Greenberg.

F. Behrend, Inc., New York, has been incorporated with a capital of \$100,000 to conduct a mining, chemical and timber business. The incorporators are J. H. Beckwith, W. and F. Behrend, 54 Front Street.

The Bernens Mining Co., Tacoma, Wash., has been incorporated with a capital of \$500,000. The incorporators are H. H. Smith, Tacoma; A. Geo. Elmer, Seattle; Judge Thos. R. Lyons, Seattle; Jas. Closkey, Juneau, and Geo. E. Dailey, Tacoma.

Big Wizard Chemical Co., Cincinnati, Ohio, has been incorporated with a capital of \$5,000. Incorporator Malcolm W. McIntyre.

Blumer Dye Co., Pensacola, Fla., has been incorporated with a capital of \$10,000 to deal in dyes. The incorporators are Wm. Blumer, T. L. Grant, Geo. Earl Hoffman.

Bowman Mell & Co., Harrisburg, Pa., has been incorporated with a capital of \$25,000 to deal in chemicals and drugs.

Brunswick Chemical Co., Newark, N. J., has been incorporated with a capital of \$200,000 to manufacture chemicals, dyes and drugs. The incorporators are Augustus C. Studer, Jr., D. B. Smith, V. B. Havens, Newark.

Central Graphite Company, 402 Jefferson County Bank Bldg., Birmingham, Ala., has been incorporated with a capital of \$300,000 to mine and refine graphite. The incorporators are Harry Watkins, Sr., H. O. Moore, E. N. Hamill.

Chase Gasoline Co., Sistersville, W. Va., has been incorporated with a capital of \$50,000. The incorporators are Jos. McKay, J. J. McKay, R. Broadwater, W. G. Maxwell and others.

Chemung Refining Co., Cushing, Ohio, has been incorporated with a capital of \$20,000. The incorporators are L. M. Ridenberger, A. F. Levery, A. J. Lavery, Cushing.

Columbia Chemical Corporation, Roanoke, Va., has been incorporated with a capital of \$500,000 to manufacture and deal in chemicals. The incorporators are H. B. Goodloe, S. W. Hairston.

The Continental Oil and Gas Co., Parkersburg, W. Va., has been incorporated with a capital of \$150,000 to operate extensive natural gas and oil fields in that State. The incorporators are C. T. Hitesgew, W. M. Smith, H. O. Hitesgew and others.

Dixie Graphite Co., Llano, Tex., has been incorporated with a capital of \$150,000 to mine and deal in graphite. The incorporators are W. McCarthy Moore, Will T. Moore and Eugene Moore.

Empire Gas and Fuel Co., Louisville, Ky., has been incorporated with a capital of \$100,000. The incorporators are Rodman Grubbs, Jos. W. Fowler, Jr., Wm. A. Rosenfield and others.

Federal Steel Products Corp., New York, has been incorporated with a capital of \$1,000,000 to manufacture steel and all its products.

Floatech Chemical Co., Inc., has been incorporated with a capital of \$10,000 to deal in acids, alkalis, chemicals. The incorporators are F. T. Dugan, F. M. Vanwagon, H. A. Flukiger, 27 Pine Street, New York.

Granite City Coke and Chemical Co., Portland, Me., has been incorporated with a capital of \$100,000 to deal in coal, coke, oils, iron, steel, etc.

Gulf Fish Oil and Fertilizer Co., Galveston, Tex., has been incorporated with a capital of \$50,000. The incorporators are J. W. Nunn, C. Biehl, P. Lobit and others.

Hercules Ore Corporation, New York, has been incorporated with a capital of \$100,000 to mine for minerals of all kinds. The incorporators are S. B. Howard, A. W. Britton, H. B. Davis, all of Wilmington.

Hood-Graves Graphite Co., Ashland, Ala., has been incorporated with a capital of \$100,000 to mine and deal in graphite. The incorporators are William Hood of Birmingham; W. D. Graves, Jacob A. Walker, A. P. Gross and others of Alexander City, Ala.

Howes Brothers and Hine Co., Portland, Me., has been incorporated with a capital of \$2,500,000 for manufacturing, tanning, dealing in hides, leather, lumber, bark, machinery, etc.

Illinois Producing & Refining Co., Wilmington, Del., has been incorporated with a capital of \$500,000 to acquire and develop lands containing oil, etc. Mr. F. D. Buck, Geo. W. Dillman, K. E. Longfield, all of Wilmington.

International Mica Mineral Company, Dover, Del., has been incorporated with a capital of \$200,000 to mine for mica and prepare the same for market. The incorporators are L. P. Phillips, J. B. Bailey, local Dover, Del., incorporators.

Intermountain Oil Co., Butte, Mont., has been incorporated with a capital of \$500,000 to engage in all kinds of mining. The incorporators are L. H. Kelly, C. S. McCoy, Maxwell Petersot and D. H. Mottelson, all of Butte.

James Chemical Dye Works, Joplin, Mo., has been incorporated with a capital of \$2,000 to deal in chemicals. The incorporators are H. T. James, Edward James and A. M. Bradley.

The James-Hazell Oil and Refining Co., Wilmington, Del., has been incorporated with a capital of \$1,000,000 to drill and bore for oil and natural gas. Incorporators are K. M. Dougherty, C. Pearson, E. Lynch, all of Wilmington.

Kanawha Oil Co., Bartlesville, Okla., has been incorporated with a capital of \$200,000. The incorporators are H. Thompson, Clinton, A. Bell and A. J. Stratton.

Kansas-Oklahoma-Texas Oil and Gas Development Co. has been incorporated with a capital of \$5,000,000. The incorporators are J. H. Butts, Wichita; J. W. Hiatt, Winfield; A. C. Coffman, Wichita; H. W. Lewis, Wichita.

Kingston Paper Co., Inc., N. Y., has been incorporated with a capital of \$30,000 to deal in paper, felt and similar products. The incorporators are H. Horwitz, P. Kingsford, Little Falls, N. Y.

Liberty Oil and Gas Corp., Wilmington, Del., has been incorporated with a capital of \$250,000.

Louisiana-Kentucky Fluorspar and Lead Co., Wilmington, Del., has been incorporated with a capital of \$250,000 to mine for ores of all kinds.

Martin-Camp Co., Hornell, N. Y., has been incorporated with a capital of \$100,000 to deal in coal, coke, wood, oil, gas, timber. The incorporators are I. L. Camp, F. R. Seely, all of Hornell, N. Y.

The Massillon Smelter Co., Massillon, Ohio, has been incorporated with a capital of \$10,000. Incorporators, William Dryant and others.

Midland Oil, Gas & Refining Co., Portland, Me., has been incorporated with a capital of \$1,000,000 to manufacture, refine, operate oil wells, minerals, etc.

Monitor Graphite Co., Ashland, Ala., has been incorporated with a capital of \$100,000. The incorporators are Wm. J. Andrews, Thomas M. Webb, both of Raleigh, N. C. The company will install a \$40,000 plant.

Muskogee Glass Manufacturing Co., Muskogee, Okla., has been incorporated.

The National Steel Products Co., Mansfield, Ohio, has been incorporated with a capital of \$1,000,000. The incorporators are C. Oberlin, R. W. Martin, Chas. A. Congsdorf, W. F. Black and D. F. Brucker.

New England Oil Paint and Varnish Co., Ridgewood, has been incorporated with a capital of \$100,000 to manufacture chemicals and alkalis. The incorporators are S. Batnet, Paterson; J. H. McClellan, Boston; L. Cohn, Ridgewood.

New Process Chemical Co., New York City, has been incorporated with a capital of \$150,000 to manufacture paints, varnishes, etc. The incorporators are W. R. Loughly, Middletown; Stafford Smith, Wm. F. Cahill.

North American Petroleum and Gas Co., Del., has been incorporated with a capital of \$2,000,000 to mine for and market petroleum. The incorporators are F. R. Hansell, Philadelphia, Pa.; Geo. H. B. Martin, S. J. Seymour, Camden, N. J.

Oronada Petroleum Corp., Tully, N. Y., has been incorporated with a capital of \$750,000 to deal in oil, gas and mineral business of all kinds. The incorporators are F. W. Assmann, L. Vinhav, Syracuse; F. W. Smith, Oswego, Ill.

Overland Trading Corp., Hoboken, N. J., has been incorporated with a capital of \$6,250 to manufacture and deal in dyestuffs, chemicals, etc. The incorporators are N. Marcus, R. E. Hetzel, H. J. Camby, Hoboken.

Charles L. Payne Chemicals and Specialties Co., Inc., New York, has been incorporated with a capital of \$10,000 to deal in drugs, chemicals, toilet articles. The incorporators are R. F. Lewis, A. Y. Du Bois, C. L. Payne, 31 Union Square.

Peerless Sal-o-cell Co., Buffalo, has been incorporated with a capital of \$50,000 to manufacture and deal in polishes, dyestuffs, soaps. The incorporators are L. S. Wilkie, C. S. Salsbury, C. W. Smith, 91 Charlotte Ave., Buffalo.

Portland Cement Co., Petoskey, Mich., has been incorporated with a capital of \$1,000,000.

Prudential Oil Co., of Texas has been incorporated in Delaware with a capital of \$1,000,000 to acquire oil lands and to develop the same. The incorporators are W. F. O'Keefe, E. E. Wright, Geo. S. Steigler, all of Wilmington.

Robert Ranth, Inc., Newark, N. J., has been incorporated with a capital of \$30,000 to manufacture and deal in rosin products, chemicals and brewers' supplies. The incorporators are Robert Sims, Newark; Emil Breitenfeld, S. Sholes, New York.

E. E. Reifenberg & Bro., Inc., has been incorporated with a capital of \$3,000 to deal in chemicals, metals, ores, minerals. The incorporators are G. W. Heining, J. D. McQuade, E. E. Reifenberg, 53 West 94th Street, New York.

Roanoke Iron and Steel Corporation, Wilmington, Del., has been incorporated with a capital of \$3,500,000 to manufacture iron, steel and steel products. The incorporators are H. E. Latta, Norman F. Coffin, Clement M. Egner, local Wilmington incorporators.

Santo Domingo Development & Investment Corp., Portland, Me., has been incorporated with a capital of \$100,000 to deal in oil wells, refineries.

Southern Smelting & Refining Co., Wilmington, Del., has been incorporated with a capital of \$1,000,000 to do a general business of mining in all its branches.

Standard Silicon Co., Delaware, has been incorporated with a capital of \$500,000 to manufacture silica and silica products. The incorporators are Andrew W. Urmann, Ridgeway, Pa.; Francis A. Guber, Geo. S. Supprecht, St. Marys, Pa.

The Steel and Tool Exchange, Manhattan, has been incorporated with a capital of \$10,000 to manufacture tungsten and high-speed steel. The incorporators are James Duffy, Fred Holman, John J. Reilly.

The Toledo Refining & Oil Co., Toledo, Ohio, has been incorporated with a capital of \$300,000. Incorporator, Geo. A. Vradenburg.

Triangle Oil and Refining Co., Del., has been incorporated with a capital of \$1,000,000 to refine, and deal in and pe-

troleum and its products. The incorporators are Chas. R. Bishop, M. L. Gatchell, E. E. Bishop, Wilmington.

B. Ullman & Co., Inc., Manhattan, has been incorporated with a capital of \$100,000 to manufacture and deal in liquid and powdered bronze, powders, metallic, leaves, etc. The incorporators are S. M. Kazarus, J. A. Abeles, W. P. Riley, 2 Rector Street, New York.

United Oil and Gas Co., Kokomo, Ind., has been incorporated with a capital of \$200,000. The incorporators are J. Frank Lindsey, Addison Jenkins, H. D. Wilcits.

The Utica Chemical Co., Inc., Utica, N. Y., has been incorporated with a capital of \$200,000. The incorporators are A. M. Thomsen, Wm. S. Bacot and H. H. Thompson.

Venezuelan Fields Limited, Wilmington, Del., has been incorporated with a capital of 1,000,000 to carry on the business of producing crude oil and its products. The incorporators are H. E. Latter, Norman W. Miller, Clement M. Egner, local Wilmington, Del.

Washington-Wyoming Oil Co., Seattle, Wash., has been incorporated with a capital of \$5,000,000. The incorporators are Geo. W. Dutton and M. O. Blum.

Welchita Asphalt Paint & Varnish Co., Wichita Falls, Tex., has been incorporated with a capital of \$30,000. The incorporators are V. H. Williams, J. D. Miller and W. E. Griggs, all of Gainesville.

Wyoming-Platte Valley Oil Co., Torrington, Wyo., has been incorporated with a capital of \$500,000. The incorporators are T. Snow, D. C. Nolan, C. G. Parker, L. A. Rott, J. M. Ingram, B. F. Smith and J. L. Sawyer.

Financial Reports, Capital Increases, Etc.

The E. I. du Pont de Nemours Company, through its subsidiary, the Dupont Chemical Works, is reported to have been negotiating for the purchase of the large plant of Marden, Orth and Hastings at Newark, N. J. The plant consists of twenty-one buildings devoted to the manufacture of intermediate and dyestuffs, and includes complete control and research laboratories.

The Grasselli Chemical Co. of Cleveland has asked for a receiver for the Aetna Explosives Co. The Grasselli Co. is creditor of \$100,000, and it is understood that there are numerous other creditors. In spite of this fact it is stated that the Aetna Explosives' assets are far in excess of its liabilities and that the receiver is endeavoring to sell the Government to have the properties sold, in view of the munition contracts for domestic and foreign shipment.

The Rollin Chemical Co., Inc., New York, has increased its capital from \$1,600,000 to \$2,000,000.

The capital stock of the Union Carbide Company has been increased from \$30,000,000 to \$50,000,000.

The Logwood Chip Co., Ltd., New York, has reduced its capital stock from \$100,000 to \$50,000.

The Standard Oil Co. of Indiana filed notice with the secretary of state of a meeting of stockholders, at which the capital stock was increased from \$20,000,000 to \$100,000,000.

Stevens Grease and Oil Company, Cleveland; increase from \$150,000 to \$250,000.

Federal Foundry Supply Company, Cleveland; \$75,000 to \$125,000.

Increase in capital of Continental Machine and Foundry Co., Chicago, Ill., from \$400,000 to \$500,000.

Application has been filed to increase the capital stock of the National Steel Company, Havana, Cuba, from \$100,000 to \$250,000.

Some of the stockholders of the Union Oil Company, outside the active officials of the corporation, it is reported, are agitating a plan to increase the capital stock of the corporation from \$50,000,000 to \$100,000,000, and to issue a stock dividend covering the present surplus of the company, which amounts to around \$17,000,000. This would mean a total dividend of about 30 per cent of the outstanding stock. In other words, every stockholder would get one additional share of treasury stock for each 10 shares he now owns.

The properties of the Union Oil Company are said to be worth \$100,000,000 or more. Patented oil lands are increasing in value rapidly on account of scarcity, and also because of the efforts of the federal government to conserve the petroleum deposits, especially in lands for which the title has not passed from the government.

Construction and Operation

Alabama

ASHLAND.—The plant of the American Graphite Company near Ashland will be in operation very soon.

BIRMINGHAM.—The Hill-Griffith Company will construct a mill for grinding crude graphite and refining it, on Seventh Avenue near Thirtieth Street. Alabama has recently become a graphite mining state and the Hill-Griffith Company is planning to take advantage of the newly developed resources.

California

LOS ANGELES.—The American Solvay Process Company of Syracuse and the Pacific Coast Borax Company are jointly constructing a potash plant here in Trona on Seales Lake. It is expected to have the plant finished in about two months. It will cost when completed with tramways and equipment over \$1,000,000. Extensive leases are held on Seales Lake deposits, which carry large quantities of borax, potash and soda.

Colorado

DENVER.—The Colorado Power Company has signed a contract for an electro-metallurgical installation for a manufacturer of ferro-tungsten, providing for 600 kilowatts of use and producing a yearly gross income of about \$25,000.

Connecticut

BRIDGEPORT.—The American Brass Company plans a new factory and foundry building 320 by 98 feet. It will cost \$115,000.

Illinois

CHICAGO.—The Annicot Smelting Plant has been purchased by Harris Brothers Company for machinery manufacturing, for \$100,000. The property consists of 8 acres of land at Chicago Heights.

CHICAGO.—James A. Brady Foundry Company has purchased a site for a group of buildings which will cost \$300,000. The site is located at the corner of Western Avenue and Forty-fifth Street.

Iowa

DAVENPORT.—It is reported that the Dewey Portland Cement Company, now operating a cement plant at Dewey, Okla., is to build a 1,250,000 barrel plant at Buffalo, Ia., ten miles southwest of Davenport.

MASON CITY.—Plant No. 2 of the American Brick and Tile Company, which was destroyed by fire in January, is now being rebuilt.

MASON CITY.—The Northwestern States Portland Cement Company is installing in its power house the Combustion Engineering Corporation's Type "F" Stoker with forced draft system.

Maine

LINCOLN.—The Eastern Manufacturing Company will build a coal discharging plant at its Lincoln Pulp Mill which will cost \$20,000. It will have a capacity of 200 tons of coal per hour.

Maryland

BALTIMORE.—The Inter-Ocean Oil Company will spend \$2,000,000 in erecting one of the largest oil plants in the section at East Brooklyn. The United States Asphalt Refining Company, a subsidiary concern, purchased 105 acres of land some time ago and the plant will be built on a part of this land. The land is north of the present plant of the asphalt company, which is located near the water front. The construction work was started some time ago and will be speeded up from now on. The company will make gasoline and various oil products. Fuel oil will also be made. The company operates a paint plant which manufactures asphalt paint for water-proofing and roofing.

Massachusetts

MALDEN.—The Eastern Smelting and Refining Company of Somerville has purchased 14 acres of marsh land and will erect a building for smelting and refining of copper and tin. The plant will employ about 200 men.

SALEM.—The Rogers-Shear Company of Warren, Pa., is the concern which has leased in part the Forest River lead mills plant. The business to be carried on is said to be the manufacture of dry colors.

Minnesota

AKELY.—The Northern Wood Products Company planned to build a factory at Akely some time this summer. The company will manufacture turpentine, tar, rosin, sheep dip, oil and other various products from the stumps received from the farmers.

Missouri

JOPLIN.—The American Metal Company, Ltd., of New York, which has been using from 8000 to 12,000 tons of zinc concentrates yearly from the Joplin mining district, entered the field as producer of ore through a deal closed recently by Victor Rakowsky, under whose direction the Picher and the Butte and Superior ore tracts in Oklahoma were developed.

First leases on 14,000 acres of land passed from Rakowsky to the American company in the deal, which probably involves the largest acreage ever obtained in the United States by any major zinc corporation for the development of zinc tonnage.

The American Metal Company is the largest zinc smelting corporation in America, with a smelting capacity in excess of 50,000 retorts in plants at Bartlesville and Blackwell, Okla., and Langloeth, Pa., near Pittsburgh. The company has smelted a major part of the product of the Butte and Superior Mining Company of Butte, Mont., whose mines, the largest in the world, were developed under Rakowsky's direction in 1903-1904.

The concentrates from the 14,000 acres are expected to largely meet the company's demand, but are not expected to cease buying on the market.

ST. LOUIS.—The Provident Chemical Works is completing a group of three new buildings on Idaho Avenue which will cost when finished over \$150,000. The buildings will be used for the manufacture of acid phosphates. C. E. Udell is president of the Company. C. J. Young is secretary. The company has been operating in St. Louis for a number of years.

New Jersey

BAYONNE.—The Marvello Products Company, 1041 Avenue C, has been organized to manufacture chemical preparations. Daniel A. Louri and Louis Gates, Jr., are heads of the company.

NEWARK.—The Hanson & Van Winkle Company, 269 Oliver Street, manufacturer of chemicals, has filed plans for improvements and extensions in its foundry on Chestnut Street.

NEWARK.—The Hanovia Chemical Manufacturing Company will build a 1-story addition to its plant at 233 New Jersey Railroad Avenue.

NEWARK.—The Texas Oil Company has purchased a site for a new plant on the Newark Meadows for the manufacture of gasoline, etc. The plant will cost \$250,000. The plant will use one of the modern cracking processes.

NEW BRUNSWICK.—The plant of the Weiler Manufacturing Company, manufacturer of explosive chemicals, has been acquired at public auction by John J. White, Inc., New York, for about \$25,000. Randolph Perkins is operating the plant for the new owners.

RUTHERFORD.—The Burns Chemical Manufacturing Company of Brooklyn, N. Y., has purchased two acres of land along the line of the New Jersey and New York Railroad and will transfer its plant from Brooklyn to East Rutherford.

TRENTON.—The Mitchell-Bissell Company, Fourth Avenue and Twentieth Street, New York City, has leased a section of the Prospect Hill Pottery plant and will establish a factory for the manufacture of porcelain specialties used in silk making. Machinery is now being installed.

New York

ELMIRA.—The Elmira Foundry Company has purchased considerable land adjoining its present foundry and plans to make large additions.

North Carolina

ASHEVILLE.—It is believed that the plant of the United States Leather Company which was recently destroyed by fire will be rebuilt.

RALEIGH.—The North Carolina Farmers' Co-operative Fertilizer Union will build a large fertilizer plant in Raleigh. The authorized capital stock is \$500,000.

Ohio

CINCINNATI.—The Newport Rolling Mill plans an addition to its plant. It will cost \$50,000.

(CLEVELAND.—The Stevens Grease and Oil Company of Cleveland will install new equipment at its plant here and also construct a new plant in Kansas City. The company recently increased its capital stock from \$100,000 to \$150,000.

MARIETTA.—The Northwestern Chemical Company is making improvements in its plant which include a new office building and a one-story warehouse, together with other additions.

MARTIN'S FERRY.—The Wheeling Steel and Iron Company is planning to build a blast furnace, a steel plant and a plate and skelp mill at Yorkville, two miles north of this place. The estimated cost of the plant is \$5,000,000. The company already has five big plants in this vicinity. Electric power is to be used for driving the new mills.

WARREN.—A new steel company plans a blast furnace of six units on a 100-acre tract near Warren. Mr. Edward E. Clark of the Trumhull Steel Company is one of the organizers of the new company. The capitalization will be \$600,000.

Pennsylvania

CHESTER.—The Crown Smelting Company is building a 2-story addition to its plant on Concord Avenue.

EASTON.—The Thomas Iron Company is planning for the early operation of a blast furnace, furnaces, Hotchkiss and the company has announced that the contemplated sale of its property to W. H. Bilyeu, Philadelphia, for a consideration of about \$2,500,000, has been abandoned.

KANE.—The glass plants in this part of the state have been shut down for several weeks due to fuel and raw material shortage. They have recently resumed operations.

PHILADELPHIA.—The American Metal Works plans an extensive addition to its plant to include a four-story factory building and a one-story metal plating shop.

PHILADELPHIA.—Edward G. Budd Manufacturing Company, manufacturer of automobile parts, has awarded a contract for the erection of a 1-story machine shop addition, 123 x 175 ft., to cost \$55,000.

PHILADELPHIA.—The Weber & Company, 125 Chestnut Street, manufacturer of paper goods, will build a new 6-story brick and concrete plant, about 40 x 150 ft., at Twelfth and Buttonwood Streets.

PHILADELPHIA.—The Gill Glass Company has had plans prepared for five 1 and 3-story additions to its plant at Amber and Venango Streets, to form a new manufacturing works.

PHILADELPHIA.—The Alan Wood Iron and Steel Company has increased the appropriation for extensions and improvements at its Ivy Rock plant from \$1,000,000 to \$3,000,000. The erection of a new plate mill is planned. A new north furnace, making the eleventh at the plant, has been started and plans are under way to inaugurate the operation of a further addition, for the eleventh furnace, in course of construction, by the close of April.

POTTSTOWN.—The Eastern Steel Company is making rapid progress in the erection of its new No. 2 Stack, and expects to place the plant in service within a month. It will be one of the largest furnaces in this district.

Tennessee

MASCOT.—The American Zinc Company will build an \$50,000 zinc mill at this place.

NASHVILLE.—The Tennessee Chemical Company will erect a plant to manufacture synthetic acid at this place.

SWEETWATER.—Work on rebuilding the Durex Chemical Company is proceeding rapidly, and it is expected to have the buildings done in a short time.

Utah

SALT LAKE CITY.—The American Smelting Refining Company will spend over \$1,000,000 in improvements to the Garfield Smelter, which will make it one of the largest in the world. Work has been delayed on account of the difficulties in getting quick deliveries of material. The increase in production of copper ore at the Bingham mines of the Utah Copper Company and the heavy demand for metals is responsible for the increase. The present capacity is 20,000 tons of ore per day. With the addition to be made the plant will have a capacity of 30,000 tons of ore per day.

Canada

HAMILTON, ONT.—The National Abrasive Company of Boston and Amesbury, Mass., manufacturers of carboron, an abrasive material for grinding and polishing purposes, have decided to locate in Hamilton and have bought an acre and a half of land on Biggar Avenue, near Lottridge Street.

They will start erecting a factory immediately and expect to start operations in 90 days, and at the start will employ about 75 men. The equipment and material are being ordered through the Ritchey Supply Company of Toronto, who are the selling agents for this company in Canada.

Nathan C. Harrison, treasurer of the Harrison Supply Company, through which concern they market their products in the United States, is also president of the National Abrasive Company and he has been connected with him J. T. Johnston, who is looking after the erecting and equipping of the Hamilton factory.

West Virginia

DURBIN.—The Pocahontas Tanning company is rebuilding its plant which was destroyed last month at a loss of \$500,000.

WHEELING.—The large plant of the United Zinc Smelting Corporation, just south of the city, is rapidly nearing completion. Included in the plant is a large acid plant.

WINIFRED JUNCTION.—The Ohio Cities Gas Company plan the erection of a chemical plant at this place. The plant will manufacture bromine, calcium and magnesium chlorides and common salt.

Wisconsin

WATERTOWN.—The Electric Steel Casting Company of Milwaukee is contemplating to establish a plant in this city if satisfactory arrangements can be made. It is capitalized at \$300,000.

Manufacturers' Notes

AMERICAN CYANAMID CO. TAKES NEW OFFICES.—The American Cyanamid Co. announces the removal of its general offices on March 20 to 511 Fifth Avenue, New York City where it occupies the tenth and eleventh floors of the Postal Life Building, at the corner of Fifth Avenue and 43d Street.

FREDERIC DE P. HONE & CO., engineers, have removed their office to 13-21 Park Row, New York.

LEAD FOR THE GOVERNMENT.—The Council of National Defense has estimated that from 15,000 to 50,000 tons of lead will be needed by the Government for the Army and Navy during the balance of the year. The price to be paid for this will be decided upon by a committee of producers acting in co-operation with Government authorities.

GENERAL CERAMICS COMPANY EXPANSION.—The General Ceramics Company, formerly the German-American Stoneware Works, was originally organized for the sole purpose of manufacturing high-grade chemical stoneware in accordance with the best German and American practice. During the past few years it has, by the purchase and development of existing plants and the erection of new factories, increased its lines of manufacture to include a large variety of ceramic products, and intends to add to this such other ceramic products as circumstances may dictate.

SOTHMAN CORPORATION FORMED.—The frequent wishes of many of the clients of the consulting firm of P. W. Sothman & Co. that it should extend its scope to include actual construction has led to the formation of The Sothman Corporation. The new offices at 40 Exchange Place, New York.

The officers and staff of P. W. Sothman & Co. have had long practical experience in the design of hydraulic, steam and gas-turbine plants, and of all kinds of transmission lines, both high and low tension, overhead, underground and submarine, as well as in the construction of dis-

tribution systems, waterworks, cooling plants, etc.

The corporation is also prepared to negotiate the sale of plants, processes and devices, subject to its examination, and report on the same.

GLASS MEN MEET AT PITTSBURGH.—The annual spring conference of the National Association of Window Glass Manufacturers was held at the Fort Ward Hotel in Pittsburgh, April 11. The morning session was devoted to a discussion of gas shortage and its effect on manufacturers of glass during the winter months. Several manufacturers wished an extension of the working scale to allow them to recoup losses suffered because of the shortage during February and March. The proposition was defeated. It was voted to increase the wages of all employees at hand factories 10 per cent.

Adequate means of combating the shortage of raw materials, including sand and soda ash, were also considered. According to members of the association in attendance at the meeting, the pronounced shortage of freight cars during the past year has caused serious interruption of business.

The afternoon session was devoted to the discussion of working conditions, which were declared favorable. J. M. Neenan, president of the Window Glass Workers' Union, addressed the meeting. The annual summer convention of the organization will be held at New York City July 24, 25 and 26.

GIBB INSTRUMENT COMPANY MOVES.—The Gibb Instrument Company of Pittsburgh has moved its offices and laboratories to 5716 Euclid Avenue, Cleveland, Ohio.

THE BRAEMER AIR CONDITIONING CORPORATION was organized to take over on Jan. 1, 1917, what was previously the Air Conditioning Department of Warren Webster & Co. of Camden, N. J.

The company has secured the good will, patent rights, all engineering data, tests, records and patents for the manufacture and sale of the Webster air conditioning apparatus for air washing, dust removal, humidifying, etc., and the Braemer system of humidity and temperature control. The main office of the company is in the Lafayette Building, Philadelphia, Pa.

RUSSIAN PLATINUM INDUSTRY.—The production of platinum in Russia and the prices of 33 per cent platinum prevailing for the last five years are as follows, according to the explanatory memorandum from the Russian Minister of Finance to the Budget for 1917. Expressed in rubles of Foreign and Domestic Commerce by the commercial attaché:

Production.		Average price.	
Years.	Poods.	Troy ounces.	Rubles per pood.
1911.....	352	158,337	36,365
1912.....	337	177,439	37,339
1913.....	298	193,741	38,583
1914.....	298	196,782	39,654
1915.....	206	108,465	67,305

PULVERIZED FUEL FOR CEMENT KILNS.—The Locomotive Pulverized Fuel Co., 39 Church Street, New York, makers of apparatus for burning pulverized fuel, states that the cement business in this country now represents an investment of about \$250,000,000 in over 150 plants which average a production of about 100,000,000 barrels of cement a year. The production of this cement involves the use of over 6,000,000 tons of pulverized fuel in the kilns, and about the same quantity of coal for the operation of the power plants. The company claims that the generally used method for burning the pulverized fuel in the kilns is quite ineffective and uneconomical, and that the opportunity for reducing the total cost of fuel per barrel of cement produced is enormous.

EXPORTS FROM SHANGHAI TO THE UNITED STATES

Articles	1915		1916	
	Quantity	Value	Quantity	Value
Antimony.....				
Crude, pounds.....	1,268,000	\$146,220	1,869,456	\$302,260
Regulus, pounds.....	3,376,000	\$73,737	1,833,400	\$57,027
Chemicals, Drugs, Dyes and Medicines:				
Albumen, pounds.....	1,514,645	629,083	1,886,377	1,003,214
Aniline dyes, pounds.....	1,301,723	1,865,723	1,831,627	540,297
Camphor, pounds.....	22,420	6,419	22,698	6,598
Indigo paste, pounds.....	2,441,821	2,482,129	406,466	546,471
Resin, benzoin, lb. pounds.....	4,708	7,607	15,941	68,069
Turmeric, pounds.....	131,666	2,914	1,556,386	56,080
Cold, Chinese bars.....		5,634,854		114,132
Iron, pig, tons.....	7,680	100,106	8,658	152,472
Oil, Vegetable:				
Bean, pounds.....	290,880	15,233	319,018	27,977
Cottonseed, pounds.....	9,151,100	430,938	10,831,622	680,663
Peanut, gallons.....	25,099	13,441	183,522	115,401
Gad, gallons.....	83,059	39,919	26,893	18,421
Silver, Chinese dollars.....		167,010		202,291
Tallow, vegetable, pounds.....	112,005	9,498	1,380,063	114,012
Zinc ore, tons.....	1,241	37,474	101	7,725

OUR TRADE WITH PRINCIPAL CHINESE PORTS.—In 1916, according to Commerce Reports, American purchases of cottonseed oil shipped from Shanghai increased by \$249,725 due to the high price in the United States. Peanut oil, which showed a value of only \$491 in 1914 and \$13,441 in 1915, advanced to \$111,401 in 1916. There are only two items of export to the United States that show large decreases. Aniline dyes and indigo paste decreased by over 3,000,000 lb., valued at over \$3,000,000. The dye trade was very speculative during the year, following on the previous years enormous profits, and the natives have invested considerable amounts in dyes, paying high prices, expecting a continued demand from Europe and the United States, which, however, did not materialize.

The following items were exported from Hongkong to the United States:

Articles	1915	1916
Antimony	\$49,301	\$104,980
Chemicals	107,215	166,788
Explosives, Fireworks	20,006	46,321
Hides		64,612
Leathers	23,796	54,872
Oil		
Peanut	90,980	91,035
Sugar	28,697	47,298
Tin	983,884	1,261,737

In regard to imports at Hongkong, the Consul General has the following to say:

"In the drug and chemical trade, American goods have been introduced in some lines, which will mean a permanent trade independent of all war conditions, for the Hongkong importers have found that in many of the drugs and chemicals, American prices and qualities are far more attractive than European prices and commodities even before the war. In the line of chemicals and drugs, a marked change in the course of trade from now on and independently of war conditions.

"Imports of American condensed milk, a great trade in China and one of increasing importance, show a considerable gain.

"Of the great mass of miscellaneous imports, novelties and sundries, such as, in part, carpets, toilet articles and toilet supplies, paper, stationery, etc., Japan has secured much of the cheaper trade formerly held by Germany, but the United States is furnishing most of the better class of goods in all such lines. In a general way Japan has maintained its lead since the war. The general trade, but American exports of such goods have more than held their own, and the trade is largely American, and much of it is on a permanent basis.

In the Canton district, a mining director was appointed for the Provinces of Kwangtung and Kwangsi, and instructed to find means for the development of the mineral wealth of these provinces, which is known to be considerable. The newly appointed mining director left Canton in September, 1916, and has made his headquarters at Kiangsi. The Chinese of Kiangsi, the mineral resources of which are believed to be considerable, but so far little or nothing has been done to develop them. The chief development during 1916 was in the mining, smelting and refining of antimony ore, which is produced in many districts in the Provinces of Kwangtung, Kwangsi and Yunnan. Owing to the demand for this article caused by the war in Europe, a great stimulus has been given to its mining and export, and dealers and miners have realized large profits. There are at present several antimony smelters established in Canton and Hongkong for the refining of the ore. It is stated that steps are being taken to encourage the development of such works in Kwangsi Province, and that the Chinese are opposed to the trade in antimony being handled by foreign firms.

From statistics at hand it is believed that the export of tin from the mines at Kiochi, Yunnan, will show a considerable falling off as compared with 1915. From Canton we received 2963 lb. of dyes (unclassified) in 1916, valued at \$12,577, as compared with none in 1915. This is the only article of direct interest in our field which came from this port in 1916.

REPORT OF INDUSTRIAL COMMISSION TO FRANCE.—A book that should be of interest and value to American manufacturers is the report of the American industrial commission to France. The report, entitled "Franco-American Trade," has been issued, according to *Commerce Reports*, in a 256-page volume, with numerous illustrations and industrial maps. The commission of fifteen members was organized by the American Manufacturers' Export Association to return the visit to this country of the French trade commission, and the commission was in France from September to October, 1916. The report deals with trade, the tariff and shipping; agriculture, mining and manufactures;

transportation, syndicates, co-operative societies, chambers of commerce, and courts of commerce; labor and social welfare; and city planning. There are also chapters on the important hotel and resort industry of France, on general and technical education, on the devastated regions, on the society for the resumption of industrial activity in the invaded regions, on Belgian reconstruction, and on the Lyon Sample Fair. The book has an excellent bibliography, and includes the thirty-five monographs dealing with France issued by the Bureau of Foreign and Domestic Commerce. Copies of the report may be purchased through the American Manufacturers' Export Association, 160 Broadway, New York City.

INCREASED GRAPHITE PRODUCTION.—The production of flake graphite has increased steadily during the last three years, owing to the great demand for it for use in making crucibles. H. C. Ferguson of the United States Geological Survey, estimates that the production of flake graphite for 1916 was about 11,500,000 lb., as compared with 7,474,370 lb. in 1915 and 5,220,539 lb. in 1914. Alabama furnished about 5,500,000 lb., and the remainder came from mines in California, Montana, New York and Pennsylvania. In all sixteen companies produced flake graphite. The imports of flake graphite, chiefly from Ceylon and Madagascar, far exceeded the domestic production. Owing chiefly to the enormous demand for crucibles for use in making munitions, the better grades of flake graphite now command more than double the prices at which they sold before the war. Most of the American graphite and in this country is imported from Mexico and Chosen (Korea), but a total of 2562 tons was obtained from mines in Michigan, Nevada, North Carolina and Rhode Island. The principal reason for the increase in the manufacture of crucibles but can be used for making lubricants, pencils, paints and foundry facings. The price of amorphous graphite has accordingly advanced. The grade of the product and has not been greatly increased by the war.

UNITED STATES EXPORTS OF COPPER.—The following table, prepared by the National Conduit & Cable Company, New York City, shows the countries to which our copper went last year and in 1915.

UNITED STATES EXPORTS OF COPPER		By Countries	
		In Tons of 2240 Lb.	
Destination	1916	1915	
United Kingdom	79,045	50,985	
France	150,086	102,440	
Germany			
Holland	2,702	1,678	
Belgium			
Austria			
Italy	51,099	44,705	
Denmark	3,416	2,426	
Norway and Sweden	10,683	19,958	
Portugal	26,220	20,450	
China and Japan	71	119	
Sundries	3,983	3,577	
Canada	327,310	276,344	
Contents of sulphate of copper	20,372	9,908	
Copper	2,171	1,200	
Total	349,853	287,452	

MANY USES FOR TURPENTINE AND ROSIN.—Although classed as "naval stores," turpentine and rosin are used today for a wide variety of purposes which have nothing whatsoever to do with shipping. More rosin, for example, is used in the manufacture of soap than in anything else, and its second most important use is in making paper suitable for printing and writing. The name "naval stores" as applied to these products is a reminder of the old days when tar and pitch, the first articles to be obtained from the pine trees, were the most important commercially than turpentine and rosin. The former articles were used in the shipping industry for caulking seams and sheathing ropes, and turpentine and rosin, as well as tar and pitch, began to be obtained from the long-leaf pine and similar trees in the Southern States, the name "naval stores" was extended to these also.

The wide variety of uses to which turpentine and rosin are put today is realized by only a few persons. The leather and paper laboratory of the Bureau of Chemistry, U. S. Department of Agriculture, has prepared lists of uses of these interesting materials. The uses of turpentine follow. The uses of rosin will be given in our next issue.

USES OF TURPENTINE.
Volatile thinner for paints, varnishes and wood fillers.

To accelerate oxidation of drying oils (as ozonizer).

Solvent for waxes in shoe and leather polishes, floor polishes and furniture polishes. Solvent for gums in lacquers and varnishes.

Ingredient of waterproof cements for leather, rubber, glass, metals, etc.
Solvent for waterproofing compositions.
Cleaner for removing paints and oils from fabrics.
Pharmaceutical purposes, including:
Disinfectants.
Liniments.
Medicated soaps.
Internal remedies.

Paints and varnishes.
Raw material for producing synthetic camphor and indirectly, Celluloid.
Explosives.
Fire-works.
Medicines.
Raw material for producing terpineol and eucalyptol.

Raw material for producing terpinhydrate used in medicines.
Raw material for producing isoprene used in making synthetic rubber.

In the manufacture of sealing wax.

In glazing putty.

Ingredient of some printing inks.

In color-printing processes in lithography.

Lubricant in grinding and drilling glass.

As a moth repellent and in moth exterminators.

Constituent of insecticides.

For cleaning firearms (alone or in combination with other materials).

In laundry glosses.

In washing preparations.

In rubber substitutes.

In wood stains.

In stove polishes.

In modeling waxes and grafting waxes.

In belting greases.

In the drying crayons.

In the manufacture of patent leathers.

As a substitute for pine oil in flotation concentration of ores.

Solvent for rubber, caoutchouc and similar substances.

Used to prevent "bleeding" in the manufacture of cotton and woolen print goods.

Laboratory reagent as substitute for more expensive reagents.

Oxygen carrier in refining petroleum illuminating oils.

Colored turpentine, reagent for wood and cork in biological technic.

Manufacturers' Catalogs

PYROELECTRIC INSTRUMENT CO., 148 East State Street, Trenton, N. J., has issued an attractive catalog on the Northrup pyrolyzer describing their different instruments and giving a price list.

ELECTRIC MACHINERY COMPANY, Minneapolis, Minn., has issued an attractive book on "Bank Your Water-Power," which is Bulletin No. 175. It describes a type of installation for water powers of low head, viz., a vertical alternator direct connected to a vertical waterwheel.

DOEHLER DIE-CASTING CO., Brooklyn, N. Y., has issued an attractive booklet entitled "Creating an Industry." It gives the history of the company and its products and technical and historical data.

THE BROWNHOIST ENGINEERING CO., Cleveland, Ohio, has issued catalog P, describing the Brownhoist overhead hand traveling cranes.

LOCOMOTIVE PULVERIZED FUEL COMPANY, 30 Church Street, New York City, has issued Bulletin 3, dated March, 1917, describing L. P. F. combination conveyor, feeder and commingler adapted to cement kilns.

TRAYLOR ENGINEERING & MANUFACTURING COMPANY, Alhambra, Pa., has issued Bulletin R, describing their crushing rolls, jaw crushers and gyratory crushers.

CLARK DUST COLLECTING CO., Fisher Bldg., Chicago, Ill., has issued a booklet on the American automatic dust filter, describing their 1917 models.

Other New Publications

THE GEOLOGIC FORMATIONS OF CALIFORNIA.—The State Mining Bureau has just issued Bulletin No. 72, with the above title. It was written by Prof. James Perrin Smith of Stanford University, and contains a complete bibliography and résumé of all our present knowledge relative to the geological formations occurring in California. It also contains much previously unpublished data, and covers 41 pages, and six cables showing geologic correlations. The bulletin is published in conjunction with the Geologic Map of California, recently issued, and is sold separately, price 25 cents, post prepaid. Address: State Mining Bureau, Perry Bldg., San Francisco, or State Mining Bureau, 520 Union League Bldg., Los Angeles.

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Contents for May 15, 1917

EDITORIAL:	
Detroit Meeting of the American Electrochemical Society	545
The Puzzling Steel Industry	545
A Great Library of Applied Science	546
READERS' NEWS AND COMMENTS:	
Rapid Analytical Filtering. By Henry M. Schleicher	548
American Chemical Porcelain. By Chas. F. Quaintance	548
Potash Possibilities in Oregon. By Edgar B. Van Osbel	549
Coming Meetings and Events	549
The Western Metallurgical Field	549
The Employers' Responsibility. By J. W. Beckman	550
Safety in the Larger Sense. By Fred. H. Rindge, Jr.	551
The Zinc Resources of the Joplin-Miami District and the St. Louis Meeting of the A. I. M. E.	554
One Billion Gallons of Synthetic Gasoline in 1918. By Wal- ter F. Rittman	555
The Vosmer Phenomenon. By William C. Moore	557
Dinner to M. C. Whitaker and F. G. Metzger	558
Modern Concentration of Colorado Tungsten Ores. By S. Fischer, Jr.	559
A Convenient and Inexpensive Electric Furnace for High Tem- peratures. By A. W. Fahrenwald	565
Annual Meeting of the Chemists' Club	566
Spring Meeting of American Electrochemical Society at De- troit, Mich., with abstracts of papers by John Lyell Har- per, Francis A. J. Fitzgerald, John A. Mathews, R. F. Flinterman, J. L. Dixon, C. A. Buck, A. Meyer, C. H. vom Baur, R. G. Williams, Ligon Johnson, Wm. Roy Mott, W. C. Moore, O. L. Kowalke, E. A. Richardson and L. T. Richardson, C. F. Hirschfeld, W. L. Badger, W. C. Brooks, M. DeKay Thompson and L. R. Byrne, M. DeKay Thompson and T. C. Atchison, W. E. Koerner, M. DeKay Thompson and O. L. Mahlman, F. C. Mathers, F. C. Mathers and K. S. Means, F. C. Mathers, K. S. Means and B. F. Richardson, F. C. Mathers and K. S. Means, F. C. Mathers and A. B. Leible, Oliver P. Watts, T. R. Briggs, H. L. Pierson and H. S. Bennett and Theodore W. Case	567
Analysis of Rutile. By E. W. Hagmaler	588
Porcelain. By A. V. Kleininger	589
The Equilibrium of the Basic Bismuth Salts. By A. Mut- scheller	594
An Enlarged Electron of Practical Size: the Faraday. By Carl Herting	598
The Grinding Wheel—A Link Between Electric Furnace and Automobile. By Richard G. Williams	599
Titanic Oxide Pigment	603
Glass Analysis. By E. W. Hagmaler	604
The Production and Properties of Magnetite Electrodes. By M. DeKay Thompson and T. C. Atchison	605
SYNOPSIS OF RECENT CHEMICAL AND METALLURGICAL LITERA- TURE	606
RECENT METALLURGICAL AND CHEMICAL PATENTS	609
An Improved Wood Tank for Chemical Plants	610
Production of Hydrogen by the Iron Contact Method. By Harry L. Barnitz	611
Surface Combustion Applied to Galvanizing. By Wm. J. Har- ris, Jr.	613
Utilizing the Waste from Coal Mines in the Pacific Northwest	614
The Liberty Loan	616
PERSONAL	617
OBITUARY	617
Current Market Report—The Iron and Steel Market, the Non-Ferrous Metal Market and The Chemical Market and Price List	617
Industrial—Financial, Construction and Operation and Manu- facturers' Notes	621

Detroit Meeting of the American Electrochemical Society

If the spring meeting of the American Chemical Society in Kansas City in April was characterized by the very sincerity and earnestness that was to be hoped for from the chemists of a nation at war, the same may be truly said of the meeting of the American Electrochemical Society held in Detroit last week, though it was very different from the Kansas City meeting in character and temperament. Societies if they really represent distinctive groups of men with a well-defined common endeavor, have their individualities like individuals. We may rejoice that we have in this country two strong chemical societies with such different temperamental individualities as the Chemical and the Electrochemical Societies. And we may rejoice that neither society called off its meeting on account of the war, as it proves that in these trying times our chemists are not losing their heads. Certainly if conventions of national societies have any justification, they are justified, nay they are absolutely necessary at this very minute for the nationwide mobilization of professions and industries. The Detroit meeting was truly enjoyable. It would have been truly profitable at any time in its success of bringing electrochemists and electric central station men into closer relations. At this moment it was doubly profitable to the whole country in its sincere get-together spirit. Now if ever, we need to be nationally and professionally united.

The Puzzling Steel Industry

The future of the steel industry and the course of the market during the war present a very inviting field for speculation. To have any chance of seeing correctly the future one should understand the present, and that, in the case of the steel industry, is impossible. Prior to the present movement, the maximum rate in the production of finished rolled steel was about 2,150,000 gross tons a month, in the spring of 1913. The present rate is between 2,600,000 and 2,700,000 tons a month, or about one-fourth more.

The condition is not in keeping with some of the accepted dicta of the trade. Steel, it has often been explained, goes chiefly into construction work, into permanent employment. Hence the industry is a prince at one time and a pauper at another, according to whether or not people are putting their money into permanent investment. If steel were a matter of everyday consumption, like grain, shoes or paper, the demand would be much more uniform. Interpreting the production statistics according to our lights, therefore, we see that the present period is one of very heavy new construction. Apparently men are erecting bridges and

buildings, with triple priced steel, calculated to yield proper interest on the investment during the next 20 or 30 years. Apparently railroads are building new lines and adding largely to their rolling stock, as well as building new stations. Unfortunately, however, we know that this is not the case. In the last six months the structural shops have been booking fabricated steel contracts at the rate of about two-thirds their capacity, and car and locomotive orders have been relatively light, while the production of rails last year, despite record exports, was 28 per cent. less than ten years earlier.

The heavy demand for steel of late has not been due to the war in Europe. The steel exported last year in the form of unfinished and finished rolled material, all the steel that is reported by weight in the export statistics, was 16 per cent of the total production. In 1912 the proportion was 11 per cent. The difference of 5 per cent does not explain much. Of course, there were abnormally large exports of finished goods involving steel and not reported by weight, loaded and unloaded shells, machinery, railway rolling stock, motor cars, etc., but the steel involved in these exports could hardly have represented 10 per cent of the production.

Apparently the common everyday needs of the people have very greatly expanded since the last period of steel activity, when a large proportion of the total output went into great structures. These people complain of advances of 30 or 50 per cent in the price of shoes, and get their old shoes half soled, whereas steel is selling at three prices and they buy more than ever.

A generally accepted belief in the steel trade used to be that price advances beyond a rather moderate percentage would check consumption and eventually wreck the market. According to the safe limits recognized for quite a number of years advances should not be allowed to exceed about 50 per cent., but steel prices are now more than triple those of a trifle more than two years ago, and they are more than double the top prices reached in 1907, the traditional safe limit.

The psychology of the steel market, however, is not as elusive as these comparisons would suggest. In the first place, war is a quickener of the mind and at the same time war prepares men for almost any eventuality. When steel prices advanced, apparently on account of the war, men became prepared for them to advance almost indefinitely. The steel market has lived through many years in the past two. In the second place, in all steel price movements of the past the steel market has been lifted by successive and necessary stages. Contracts were made for forward delivery, and in the case of each advance the buyers would, as a rule, be covered by contracts for additional periods. The mills would become sold up farther and farther ahead until a time came when on an additional advance the buyers would not take hold and then there would be a period of longer or shorter duration while buyers simply existed on old contracts and eventually the market would break. In this movement the mills recognized no obligation to cover their customers afresh upon each advance and thus advances were much more rapid in proportion to

the tonnage sold. Buyers have been panic-stricken, more or less, for a year and a half, fearful lest they should not be able to secure deliveries at all. The influence of the war has been more upon the mind than upon the material.

The steel market having reached its present position through such unusual steps, and the character of the demand being so abnormal, the future course is necessarily in doubt. If the war should end in a relatively short time, it would end before the present steel contracts are all completed. If it continues a relatively long time our mental and physical efforts will become so completely devoted to the prosecution of war that the ordinary commercial demand will be very greatly diminished. One thing seems clear, that if we are able to export steel and steel products freely the war will not last a great while. If we cannot do so, and if the war should last for a period of years, it seems improbable that we shall have occasion to continue the full rate of our present domestic consumption of steel.

A Great Library of Applied Science

The delightful old book-worm who reads through his pleasant hour and then dreams away in his library corner, fashioning his thoughts like sunset clouds to take shape as they will, to glow in beauty and then retire into the darkness of night, has gone into his hermitage. We seldom see him any more. His books have found their places in museums, and occasionally the Grolier Club shows a few of them so that we may not wholly forget the arts of binding and of printing. The only thing that remains is the name—library—and that has become a great, live business institution into which men rush and read with great intensity, the while they diligently make notes.

Sometimes we wish that there were a little more of philosophy and art and the subtle inner meaning of the great dramas of the Greeks of the golden age, to be found in the busy books of working libraries all over the world. Sometimes it seems that a profounder study of the ways and passions of men might have saved us from the terror and turmoil of these unhappy days of anger and death; but we record these sentiments only in passing. The big business of to-day is upon us, and the best we can do is to meet it. Men dash into the storehouses of learning to seek light upon problems of business and war, to wheedle, for instance, some quality of tin into lead, to cheapen or multiply containers for food, to gain knowledge to build machines or power installations or warehouses, to move goods, build ships and to fashion bulwarks of rock and steel against the wrath of their own kind.

The technical library is likely to be a busier place than the sales room of a great corporation. Just as the laboratory has edged its way into the works and insists upon a place there, so the library has crept into the laboratory or the draughting room. But these little libraries are not enough, for as soon as one begins to work in science he learns that the least complete of all

works are compendiums and even dictionaries. The only way to get scientific information into hand is to gather up all the periodicals and bind them, and then the work is only begun. Indeed, when everything possible for a modern scientific library is collected to date, the fact remains that the date changes every twenty-four hours and more periodicals are due. They keep coming in and coming in and need to be put in order and bound all the time—and still we have only the raw materials.

When the American Institutes of Mining Engineers and of Electrical Engineers and the Society of Mechanical Engineers came together under one roof at 29 West Thirty-ninth Street, New York, they brought their books with them, and the operation of their three separate libraries under one administration was disturbing, disquieting, difficult and distressing to the administrators. Then the three were consolidated and order began to loom into sight. Following this the American Society of Civil Engineers has now added their large collection and research department and that has produced, by the union of the four collections, a great engineering library of about 125,000 volumes, especially rich in periodical literature. It is under the control of the United Engineering Society, which is a holding association for the joint activities of the four others. About thirteen hundred periodicals are received. Complete sets of nearly all the periodicals are on hand. The book collection is constantly increased by the purchase of relevant new material, both American and European. The funds for maintenance are supplied by the four founder societies.

What is lacking is a chemical library. That of the Chemists' Club is available and reasonably convenient: one long block across Fifth Avenue and two short blocks north. This is a very large library, but even so active and growing an organization as the Chemists' Club can hardly appropriate funds to buy everything that is published in pure and applied chemistry. Now the interlocking of applied chemistry and engineering in all its branches is so close that there is no clear line to be drawn between them, although many ramifications of chemistry naturally extend far outside the pale of engineering. It seems almost absurd how even biological and physiological chemistry occasionally appear in technical problems to be treated by engineers, and yet the line must be drawn somewhere and the Chemists' Club's library must cover the whole field. The chemical feature of the library of the engineering societies is a problem still to be worked out.

The director is Mr. Harrison W. Craver, who came on from Pittsburgh some six weeks ago to take general charge. The books are all there, and while some may not be so conveniently located that they come down from their respective shelves in response to a whistle, they are nevertheless available, and anybody who wishes to consult any of the 125,000 books can do so without serious delay. The Library Research Bureau has been greatly increased by the addition of that of the American Society of Civil Engineers. It has grown and is growing. It is designed to establish its operation as nearly as

possible upon a cost basis. Its purpose is professional service and it provides information more particularly in the following forms:

Current research cards, which are sent out against deposits previously made, to give information of articles bearing upon special subjects as they are printed in various periodicals.

Bibliographies.

Abstracts of articles relating to special subjects published over as long a period as desired.

Copies, especially photo-print work.

Translations.

Inquiries come in from India, China, Japan, South Africa, South America, the War District of Europe, the far North; in short, from all parts of the earth where engineers are busy and occasionally wireless calls are received asking for searches to be made ready against the arrival of some engineer who is still at sea. The Society of Civil Engineers has been maintaining this kind of library research work for fifteen years or more, and the accession of their library contributed a large number of records which facilitates the task of bringing replies to many questions up to date. At the same time a library search record is not always what it seems to be. In order to determine how broadly it covers the field indicated by the title, it is necessary to refer back to the original inquiry, which may have been of a restricted nature. No private research is undertaken because a copy of every record is placed on file and straightway becomes available information. Whether private research will be undertaken or not remains to be determined; it is not done now and may not be done at all on the ground that the library is a public institution and has no closed books. Anyone who wants to make a private search is at liberty to do so or to employ whomever he chooses for the purpose.

The Library of the United Engineering Society is in good order, is well kept up and its methods for getting at what is wanted are simple and direct, but if the plans for the future are carried out it would almost seem that a beehive in August would appear a sleepy place beside it. While it is not a storehouse of elementary information and it does not profess to be other than a professional institution, it is designed to make of it a place where any engineer can come and get whatever is known on a subject that is recorded in print. And whatever it does for the engineer who can consult it, it must be in a position to do for the one who cannot visit it, by means of the Service Bureau. Everything printed must not only be collected—which is getting the raw material—but catalogued and cross-indexed until the cows come home. Only by this means do books become finished library product. The work in hand is very great and, let us hope, it may never be finished. But with the growth and extension of this to a great library of applied science and with the clever indexing planned by the director of the contents of the immense literature as it appears, as well as that already of record, it is almost bewildering to consider the benefits which it may confer upon industry.

Readers' Views and Comments

Rapid Analytical Filtering

To the Editor of Metallurgical & Chemical Engineering

Sir: In a busy laboratory where many filtrations are made each day, any means of increasing the speed of filtering and of folding the filter papers is most desirable. Very often the chemist will use a slow-filtering fold if he saves time and effort in making it.

Undoubtedly the most rapid fold generally known at present is the so-called "four-fold." When placed in the funnel the paper has four folds where the paper is three ply, between these the paper is of single thickness. For all classes of precipitates this fold has demonstrated its superior speed of filtration and is of especial advantage in the case of the gelatinous precipitates.

It has, however, been rejected by many chemists for the filtering of such substances as barium sulphate and some sulphides on account of the tendency exhibited by these precipitates to go through a paper which is folded in this manner. This difficulty with the fold is due to the large number of creases and bends which have weakened and broken the paper to some extent. This is particularly true at the apex of the filter where the paper has been literally worn out by the bending.

In carrying on metallurgical research in the Department of Mining and Metallurgy it was necessary at times to make very numerous filtrations. While endeavoring to devise a press for creasing the filter papers quickly, the writer discovered a scheme for folding the "four-fold" filters which not only does away with the difficulty with fine precipitates but also affords a simple and rapid means of producing the fold. Inasmuch as it has met with a very warm welcome among chemists and metallurgists to whom it has been shown, the writer ventures to submit it to others who perhaps would also find it of advantage.

The scheme consists in taking a circular piece of thin tough cardboard of the same size as (or larger than) the filter paper used, and folding it in the regular "four-fold" manner, making the creases distinct. The filter paper is placed on the disc (held flat) so as to fit it uniformly, and the folds bent consecutively, holding each fold in place while bending the next one. Two or more papers may (and preferably should) be folded at a time. A filter paper so folded has smooth round creases which do not extend to the center.

A paper so folded is placed in a funnel, wet with

cold water, and the upper edge firmly pressed to the glass. This is essential, for if air is drawn down during filtration, the effectiveness of the fold is materially decreased.

Examination of a filter so folded and adjusted reveals a smooth flat apex and rounded creases just above it. The objection stated above in filtering fine precipitates is overcome if a good grade of paper is being used and the filter gives a faster action than with the paper folded otherwise. The only sharp bends present are made while the paper is wet and therefore it is more pliable.

The filters may be folded in this manner more quickly than the simpler double fold, and when two or three papers are folded simultaneously much time and effort are saved.

One well-known brand of filter-papers is bound in packages with a cardboard disc above and below the papers. These discs are especially well suited to the purpose described and give a very long service. Perhaps a piece of leather could be utilized.

For the benefit of those who may not be acquainted with the "four-fold" filters, the following directions for folding are given:

1. Bend the disc (or paper) once on a diameter, sharpening the crease.
2. Open disc and repeat bending, making the new crease at right angles and in *same direction* as the first. In other words, the ridges formed by the bends should both be on the same side of the paper.
3. Open disc again, make a short crease mark at the edge of the paper midway between the terminals of any two adjacent creases. Make only one such mark.
4. Hold disc so that the ridges of the diametrical creases are on the upper side of the disc, and bring the crease mark up and over to the end of a diametrical crease second away from it. Hold it there and squeeze disc together, making a new diametrical crease.
5. Open disc again and make another bend at right angles to and in *same direction* as the last one. These last two bend ridges are thus on the opposite side of the paper from the first two.
6. Open the disc and it is ready to be formed into a cone. The accompanying sketch shows a disc or filter folded according to the directions.

HENRY M. SCHLEICHER,

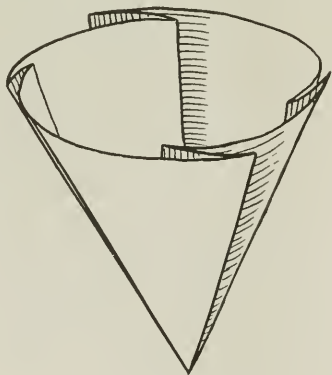
Massachusetts Institute of Technology,
Cambridge, Mass.

American Chemical Porcelain

To the Editor of Metallurgical & Chemical Engineering

SIR: Referring to the paper by Prof. Charles F. Binns on "Chemical Porcelain; Its Production and Quality," published in your April 1 issue, I would like to call attention to some of the accomplishments of American-made porcelain in contradiction to a few of the assertions in Professor Binns' paper.

Early in 1913, the Golden plant of the Herold China & Pottery Company, which was then manufacturing the first fire-proof china cooking utensils made in this country, was asked by the melting and refining department of the U. S. Mint at Denver, Col., to make up porous cells for electrolytic work similar to cells they had been importing from the Royal Berlin factory in Germany. These cells were supplied, placed in use and found to last three times as long and give better results than the Berlin cells. Following this start an



FOLDING THE FOUR-FOLD FILTER

order was accepted from the Colorado School of Mines for their porcelain requirements for 1913-14 and this was proved fairly satisfactory. After the war started six months of research improved the chemical ware in resistance to heat, acids and alkalis.

With these results new buildings, kilns and the very finest equipment were added and to-day this plant is producing monthly over 100,000 pieces of chemical porcelain which is meeting the most exacting requirements of the chemists and is being shipped all over the world just as fast as it is being drawn from the kilns.

The porcelain made at this plant to-day commands a very unique position in that it is made entirely from materials found within six miles of the plant at Golden and the pottery is different from all the other high-grade potteries in this country, in that it is equipped to cure and prepare all the raw materials used, while in the case of the other potteries they buy their materials at points ranging from Maine to Florida and use a certain percentage of imported clay. With the exception of the coal which comes from the Walsenburg district in Colorado the Golden plant is a complete unit.

In comparative tests made with German, Danish and Japanese porcelains this porcelain has stood every test equally well. The impressions that the imported ware is superior and that we can not make chemical porcelain in the United States is wrong, and I venture to say that after the war the world will accept American porcelain and glassware as standard.

It is true that the finish and symmetry on U. S. A. chemical porcelain is not all that is desired, but this is due to no other cause than to the demand being so tremendous and urgent that the potteries are not able to get any stocks ahead and cannot make the selections now that they will be able to do later.

There has been a great deal said about American porcelains not being fired to as high a temperature as the imported porcelains, but I have found it very interesting to take two pieces of each of these wares and fire them in a glass kiln with Coors ware and in every case the glass fused at the same temperature as Coors, and as the glaze must stand the highest fire there is no question in my mind that Coors porcelain is fired to equally as high a temperature as any other porcelain.

During the past year the Golden plant has put forth great efforts in developing new items. It is the aim to assist in developing the chemical resources of this country by furnishing special porcelain apparatus which will be required. At the present time special attention is given to porous cells and plates for special problems in filtration and electrolytic processes, also to pyrometer and combustion tubing.

CHAS. F. QUAINANCE.

Herold China & Pottery Co.,
Golden, Col.

Potash Possibilities in Oregon

To the Editor of Metallurgical & Chemical Engineering

Sir: Speaking of the American potash famine, leads me to wonder if any might be found in this locality.

Underlying this valley is a large quantity of water heavily impregnated with calcium chloride with traces of potassium and sodium chlorides. It might be worth while for some one interested to investigate. I can send samples of the water to any desiring.

EDGAR B. VANOSBEL.

McMinnville College,
McMinnville, Ore.

New Chemistry Building in Montana.—Montana State College is preparing plans for a new chemistry building to replace the one burned last October.

Coming Meetings and Events

Technical Association of Pulp and Paper Industry, annual spring meeting, Neenah, Wis., May 24 and 25, 1917.

American Iron and Steel Institute, New York, May 25-26, 1917.

American Institute of Chemical Engineers, semi-annual meeting, Buffalo, June 20-22, 1917.

American Society for Testing Materials, Atlantic City, June 26-30, 1917.

Third National Exposition of Chemical Industries, Grand Central Palace, New York, week of Sept. 24, 1917.

American Institute of Metals and Foundrymen's Association, Boston, week of Sept. 24, 1917.

American Electrochemical Society, autumn meeting, Pittsburgh, Oct. 3-6, 1917.

American Institute of Mining Engineers, annual meeting, St. Louis, Oct. 8-13, 1917.

Western Metallurgical Field

Hallerite

A very interesting mineral has lately been discovered in the southwestern part of Colorado, about six miles from Cortez, Montezuma County, Colorado. It was named "hallerite" after Jess Haller, the discoverer of the deposit. The mineral has aroused a great deal of interest due to the beneficial effects it produces when used as a flux in connection with the heat treatment of various metals and alloys.

The mineral deposit aggregates approximately 4,000,000 tons and is of a sedimentary formation. The region in which this material occurs was originally a lake out of which this mineral was deposited in stratified layers. Two types of mineral are observed which differ only in appearance but are of practically the same chemical composition. In general both materials are gray in color and show yellowish pink streaks or specks. The streaky mineral goes under the name of "Lena" the name being taken from the claim on which this rock occurs. The spotted type is known as "Red Speck."

The mineral from a chemical point of view is undoubtedly an impure aluminium silicate. Analyses of the "Lena" and "Red Speck" products have been made by different concerns with similar results which are given below:

Analysis No. 1, made by Von Shulz and Low, Denver, Colo., is as follows: Moisture, 0.65 per cent; combined water, 6.15 per cent; silica, 73.86 per cent; ferric oxide, 2.25 per cent; alumina, 15.80 per cent; manganese oxide, trace; calcium oxide, 0.23 per cent; magnesium oxide, 0.38 per cent; sodium oxide, 0.16 per cent; potassium oxide, 0.14 per cent; undetermined, 0.38 per cent; total 100 per cent.

Analysis No. 2, made by the Russell Chemical Company, New York City, is as follows: Loss at 212 deg. Fahr., 0.50 per cent; loss through ignition, 9.32 per cent; silica, 71.80 per cent; alumina, 9.58 per cent; iron oxide, 1.43 per cent; manganese oxide, 1.18 per cent; calcium oxide, 6.53 per cent; magnesia, trace; sulphur anhydride, trace; total, 100.34 per cent. In the loss of ignition carbon-dioxide constitutes 6.29 per cent, leaving 3.03 per cent to be accounted for. There may be some vanadium in the 9.58 per cent of alumina, otherwise the tendency to increase the tensile strength of the steel would probably lie in the manganese-oxide.

Analysis No. 3, of "Red Speck," by W. L. Piers of Denver, Colo., follows: Silica, 73.08 per cent; aluminium (oxide), 17.14 per cent; carbon dioxide, 3.02 per

cent; iron (oxide), 3.16 per cent; water, 1.30 per cent; magnesia, 0.64 per cent; vanadium V_2O_5 , 0.20 per cent; potash, 0.64 per cent; sodium, 0.86 per cent; arsenic, 0.72 per cent; uranium, trace; titanium, trace; gold, 0.06 per cent; total 100.76 per cent.

TABLE I.—TENSILE STRENGTH TESTS

Material	Per Cent Flux Used	Tensile Strength, Lb. per Sq. In.	Remarks
Cast iron	None	26,140	
Cast iron	None	21,130	
Cast iron	None	29,170	
Cast iron	1	29,230	
Grey cast iron	None	19,160	
Grey cast iron	1	23,770	
Cast steel:			
Low carbon	None	35,360	No flaw.
Low carbon	1	45,030	Badly flawed.
Low carbon	1	47,840	Bad core.
Low carbon	10	40,050	Badly flawed.
High carbon	None	44,860	Flawed.
High carbon	1	47,300	Flawed.
Brass	None	26,170	
Brass	1	27,070	
Copper	None	18,890	
Copper	1	19,830	
Aluminium	None	11,930	
Aluminium	1	12,720	

TABLE II.—COMPRESSION TEST.

Kind of material, "Semi-steel."
Shape of test piece, cylinders.
Dimensions of test piece: P—length .997, diameter .751; T—length .995, diameter .749.
Pressure applied in what way? On flat ends.
Total load at failure: P = 60,590 lb.; T = 68,430.
Load per square inch—lb. = 136,800 = 143,900.
Nature of failure, diagonal shear in each case (usual failure).

The beneficial effects of this mineral on the heat treatment of steel was first observed in a forge at Cortez, where ordinary knife blades were so hardened by the treatment that they could be used for shaving. More scientific tests were then run on cast iron, steel, brass, copper and aluminium at the testing laboratory of the Colorado School of Mines. The results of the tensile strength tests are enumerated in Table I, standard test samples being used.

A compression test on "semi-steel" is given in Table II, where P stands for plain or untreated material, while T represents the test on the product treated with the flux.

All the tests were, wherever flux was used, conducted in the same manner. The metal or alloy was first melted and then the flux added and stirred into the molten mass. The ratio of flux to metal with two exceptions was 1:10. In one test only was the ratio 10:100 and gave less satisfactory results than where the first ratio was employed. In the compression test 4 ounces of hallerite were used for 40 lb. of steel.

A few qualitative tests are also of interest. For instance, heating two similar pieces of tool steel to the same high temperature and quenching one in ordinary water and the other in water into which finely divided hallerite has been stirred, a much greater hardness is claimed to be obtained in the second case than in the first. Furthermore tempering two pieces of tool steel under exactly the same conditions, one in plain water and the other in water containing hallerite, produces some interesting results. In the first instance it took four blows of a hammer to break the steel while in the second 20 blows showed no effect.

The action of the flux has not been satisfactorily explained, but it is claimed that it is due to the deoxidizing of the impurities. It may be, that the composition of the mineral is such that it produces a very flexible deoxidizing effect. To explain: only so much of the deoxidizing action comes into effect as is required to purify the metal. If only small amounts of impurities are present in 100 lb. of metal and 1 lb. of flux is used in the treatment, only so much of the deoxidizing ingredients are used as these impurities demand, while

more will be consumed if the 100 lb. of metal contain a greater amount of the non-desirable constituents. The effect of the flux will last until all of the deoxidizing substance or substances formed in the flux during treatment are used up. Without a doubt, the mineral is worthy of further investigation, and it may be of interest to state that the government is contemplating the study and application of the mineral.

Company Reports

Report of the Hollinger Consolidated Gold Mines, Ltd. for 1916.—The mill treated 601,854 tons of ore for the year or 1649 tons per day. The average value per ton was \$8.84. The total values sent to the mill amounted to \$5,322,716.05. The percentage of the average running time was 91.1 per cent. The average tons per 24 hours running time was therefore 1810. The stamp duty per 24 hours' running time was 16.7. The unrecovered values fall into two parts, lost concentrates and losses in the tailings. The first amounted to \$7,367.00, while the latter aggregated to \$241,958.00. The concentrates mentioned were not actually lost but stored for re-treatment. The losses according to these data amount to \$249,315.00. The total recovery for the year was \$5,073,401.05, of which \$5,046,651.75 is attributed to the gold and \$26,749.30 to the silver.

The value per ton of tailings was \$0.40. The lime consumption was 2.113 lb., that of zinc 0.405 lb. and that of lead acetate 0.0042 lb. per ton of ore. The tons of solution precipitated per ton of ore was 2.221. The zinc added per ton of ore amounted to 0.182 lb. The average value of the pregnant solution was \$3.782.

The Employers' Responsibility

By J. W. Beckman

It is a well known custom among employers in the chemical industry to tie up their employees with contracts by which all the products of the employee's brain are assigned without any further consideration to the employer.

In most cases the employee is pleased to do this, since it offers to him an opportunity to carry on work and gain experience which he is especially desirous of obtaining; not to mention the fact of his obtaining his livelihood according to a method which is intellectually most agreeable to him.

When the employee signs such an agreement, he does not assign his body and soul to the employer. He has assigned a day, a year, or a number of years, as he sees fit, and also as the employer sees fit, to this special work.

The employer has the liberty at any time to discharge his employees, with often scant notice. The employee has supposedly the same liberty of ceasing working for his employer, giving the employer due notice.

The employee on leaving the employer carries with him the experience which he has gained during such employment. The employer has, for each day he has paid in salary, received service from the employee's brain. There has been a supposedly fair exchange in dollars and brains between the employer and the employee.

The modern chemical employer in most cases belongs to a class of selfish, self-seeking individuals possessing the wonderful sesame—the gold which gives him access to the inner chamber of all future employers of his employees.

Now it so happens that some employers understand the value of intelligent employees. It also so happens that some employers are willing to pay well for such employees and so obtain the best of their services and loyalty in every respect; but in contrast with these

there is a very large number of employers who appreciate in the silent chambers of their hearts the value of good brains, but are utterly unwilling to pay any compensatory sum for the services of this gray matter.

Many employees there are who are willing, through selfish motives—primarily for the purpose of obtaining experience—to go to the employers and sell their brain at low figures; while simultaneously considering that their pay comes to them in the shape of experience which they could not obtain otherwise.

In other cases the employee has started young in an organization and stayed with it continuously for many years. He feels a pride in the growth of the concern with which he is connected; and his ability is appreciated by the employer in an abstract way. From time to time his pay has been increased—never voluntarily, but only due to a refined blackmail—outside firms bidding for the employee's services.

Like a piece of furniture that remains a long time in an office becomes one of the customary sights and is treated with disregard, so is often the case with an employee of long standing. He is not given due consideration; and one day when conditions humiliating and distracting pile up on him, he goes to the employer and announces his desire to abandon his position with the employer. There is a moment's consternation in the employer's mind, but he soon settles down placidly, since he knows that he holds the whip-hand. He knows that the employee depends on his recommendation for any future work that he may desire to obtain.

Here is an example: An engineer had been employed for a great many years by a prominent firm. He started quite young in the organization, and through aptitude and perseverance has reached the very top of the department in which he was employed. This specific employer appreciated the experience his employee had obtained and also appreciated the value of this employee to his firm, though not in a way tangible to the employee.

Many disagreeable occurrences were forgotten by the employee, partly on account of interest in his work and partly on account of the responsibilities toward those depending on him for their livelihood.

One day the "straw that breaks the camel's back" was thrust upon him and he went into his employer's office and told him that he desired to leave the company. The employer considered the matter and told him that he much preferred that he stay with him; but the employee persisted and started the quest for a new position.

His relationship with his employer had always been agreeable and even the conversation, in which he notified his employer that he was going to sever his connection, was in all respects agreeable.

On applying for a position with various concerns, he naturally referred to his employer for reference. The employer unwilling to part with this employee's services, and to prevent a possible competitor from obtaining the benefit of the experience of this employee, did not say anything distinctly detrimental in his letter of reply to various inquiries, but rather damned his employee by what he did not say.

The result was that the employee did not obtain, and could not obtain, any position even approaching that which he had recently held.

The employer held the whip-hand and used his position to rob the employee and his family of their legitimate bread and butter.

It is just as likely that this employer contributes freely to the Belgian Relief Committee; but undoes, through these actions, at home what he is trying to do abroad.

No employer can in this land of Freedom even lay claim to the right of ownership of his employees, be it

mental or physical. The employee, even if he stays with his employer for half a lifetime, has the right to demand of his employer fair treatment upon leaving such employment, just as much as the employer has the right to demand a former employee to keep specific information which he may have obtained during prior employment secret, being property belonging to the former employer only; though experience is the employee's, and no claim of any kind can be made on this by former employers.

The relationship between employer and employee is, as in all relationships in life, a give-and-take. It is not one-sided. The employer's responsibilities toward the employee are just as great, if not greater, than those of the employee toward the employer, be he present or past.

San Francisco, Cal.

Safety in the Larger Sense

By Fred. H. Rindge, Jr.

These are days of great unrest in America. Labor and capital are at sword points in many places. But let us not be deceived. There is still more peace than strife in industry. There is a great undercurrent of mutuality, good-will, and it is having expression to-day in remarkable ways.

Recently the vice-president of a great plant showed me a compensation plan that had just gone into operation. On the death of an employee, even though he had worked for the company only two years, the wife receives during her life 30 per cent of his wages, and every child 10 per cent until the child becomes 16 years of age. But you will ask, "Is that a practical plan?" I don't know, but as that big, robust vice-president sat there and told me about it there was a tear in his eye. Said he: "This plan went into operation the first of January. On the 31st of December one of our men died, leaving a wife and three children under eight. He had been with us five years. We brought it up before our committee, and to a man they agreed that the benefit should be given the family, and that frail little wife received the assurance that as long as she lived (unless she remarried), she should have 30 per cent of the husband's earnings, and another 10 per cent each for their three little children until they became 16 years of age. That spirit of mutuality is being manifested all over the country, and it is the best preventive of labor troubles and serious accidents."

This good-will is not all on the side of the employers by any means, for the men are just as capable of high motives. Not long ago, a worker in an Alabama coal mine saw an accident happen to a car going down grade. The danger was great. The man on the car jumped for his life. The car would certainly smash property down below and no one knew what else might happen. Another employee leaped on the car, slipped the trolley pole, applied the brakes, and stopped the runaway, saving property and probably life. He placed his own life in peril because of the spirit of good-will, and of mutuality that was in him. We want able-bodied men and labor-saving machinery, and all of the great inventions that it is possible for us to have, but the greatest need in industry is the releasing of the pent-up spiritual forces along right lines. The bringing together of men in closer contact with each other, as employer and employee, will do more for the increase of efficiency, happiness and safety than anything else.

A recent report of the National Civic Federation says: "Industry does not and cannot operate in a vacuum. It is a human activity. It must draw the breath of life from the surrounding atmosphere and must do its share to keep this social atmosphere clean, wholesome and buoyant."

Not long ago I attended a meeting at which John D. Rockefeller, Jr., and Warren Stone, chief of the Brotherhood of Locomotive Engineers, spoke on the same Y. M. C. A. platform. After Mr. Rockefeller had finished Mr. Stone said: "I can heartily agree with practically everything he has said." After all, when labor and capital can see eye to eye they are not nearly so far apart as they think they are. In matters of safety and welfare they surely have a basis of agreement and a like interest. Both employer and employee must cooperate in this.

Wherever there is steady progress new standards as steadily arise. Our industrial progress has brought many changes in standards, especially of organization, methods and machinery. At first these changes moved slowly like a succession of dissolving views, but now they make a veritable motion picture. This progress in organization, method and machinery, has been directed in the main toward one objective—production. This has been the wonder word of industry and the rigid measure of success. The test of ability of manager, superintendent, foreman and workman, has been the output. It is this that got us last year \$2 from the factories for every dollar from the farm. Of course this has meant pressure; every man in a responsible place in industry has felt it; the workers have felt it, too.

The steel industry, for example, has always afforded a striking illustration of both output and pressure and Andrew Carnegie was an early illustrator. He was a master of production; he was also the prince of high pressure. When a manager wired him that they had beaten all records that week, Carnegie replied: "Why not do it every week?" It is a striking fact to-day, however, that industry is taking on a larger objective—it must have not only production, but *efficiency in production*. This, as I understand it, means the largest possible output with the smallest possible waste—of time, material or energy. Mr. Carnegie testified in Washington early in 1912 that now he would not do business exactly as he used to. Doubtless the changes he would make would include not less output but a lessening of the pressure and greater attention to the avoidance of waste—especially human waste. This means not only fewer accidents but a real conservation of the workers themselves. Yes, even more than this it means as one far-seeing manager expressed it, "Making men as well as profits."

Industry is saving material to-day as never before. I have just come from a coal mining territory where the State reports five years ago showed that 50 per cent of the coal was being wasted in mining. Now mines in that State are losing 8 per cent. It will not do in the future to destroy a ton of coal for every one marketed as is still being done in some fields. Organization, machinery and method must be adjusted so as to market that ton of coal with the least possible loss of time, material and energy. Lumbermen, as another example, are no longer content with increasing the production. They are busy with conservation. They are preventing wastes by fire, by neglect and by unskilled handling. They are doing their best to reduce the waste in felling the trees and sawing the timber. And they are reforesting scientifically for the sake of the future.

Industry is also guarding the time element more carefully than ever. Every time-consuming feature that can be dispensed with is quickly cut off. There must be no lost motion. Scientific management has helped the man of the steel mill to handle 47¾ tons of pig iron a day who had been handling 12½ tons. Industry has also felt the necessity for avoiding the waste of energy. How skillful we have become in wrestling the

heat units from escaping smoke, steam and sawdust. We are even taking the gas that used to spread over hill and valley, killing grass and leaf and flower, and are converting it into sulphuric acid, at great profit. At times the by-product has been more profitable than the copper metal.

Genius has been shown in conserving material, time and energy, but *how about the human element in industry?* Should not the new standard, Efficiency in Production, apply to the human factor as well as to the organization, machinery and material? Employers everywhere answer "yes." They are beginning to put a premium upon that production which secures the maximum output, *with minimum waste of life, limb or human welfare*.

The genius in industry which has given to the world the wonder of machine values is beginning to address itself to the more important if more difficult subject of human value. This marks the dawning of industry's brightest day.

But just as formerly it was difficult to induce conservative managements to discard old machines for new, so it is to-day with the new methods of dealing with the human factor. Progress is being made, however. Witness, the new standards of factory construction, the sanitation, the safety devices, and the new types of villages, housing, health measures, education, etc.

But I believe many employers are failing to realize that safety is much more than a matter of devices, bulletins and committees. It is fundamentally a matter of the spirit of the worker, and that in the last analysis means not only loyalty but personal character. We are coming to believe that *improving of character increases efficiency*, and we must now recognize that it also enhances safety in the largest sense. After all, the greatest forces in industry are like the electric current—unseen. Integrity, for example, cannot be reduced to a formula but it is a real financial factor. It will take a remarkable stopwatch and piecework system to offset the lack of integrity on the part of employees whether it be dishonesty or careless indifference. Intelligence cannot be put under the microscope but the lack of it is bound to show in the dividend column. Some really see this. Others "having eyes see not." The dollar and cent value of that intangible thing we call stability is and always has been great. An operator in Virginia said recently that 50 per cent of his total cost of operation is in changing labor. One mill manager told me that in one year he hired 96 men to keep 12 positions. What a penalty industry pays for the floater!

Mr. Charles R. Towson, senior secretary of the Industrial Department of the International Y. M. C. A., has well said: "The greatest of all these unseen forces is the good will of the worker. Suppose you could keep every worker on the job. Assume that there were no changes. What will it amount to if the spirit of the workers is not right? The spirit of the workers is industry's greatest asset—or liability. This fact cannot be stressed too much. The physical welfare of the worker should be of great concern to every employer for in no single industry can it be said of the workers 'they are physically fit.' The workers' lack of intelligence and training causes employers sleepless nights, for regardless of whose fault it is, they are far from a hundred per cent. But the *greatest loss comes to industry when the spirit is wrong*. The sub-standard body costs industry its thousands; intelligence below par costs its tens of thousands; but what are these compared with the loss that comes when the spirit of good will is lacking! Then comes careless neglect; then 'withholding efficiency'; then open strife; then destruc-

tion. This is the day for a new estimate of *spiritual values* in industry."

This is one reason why the Young Men's Christian Association is making such rapid strides in industry to-day. It helps men to do things for themselves. It works with both employer and employee. It is a character-making agency. It avows its purpose to develop the creative and combat the destructive in the lives of the workers. It helps to get the greatest output with the smallest waste. Because it is a character developing force it makes for efficiency. Modern industry's call for efficiency must be answered in various ways and by different means, and the Association is just one of the agencies that can and does help. Of course its place in industry will be measured by its service. The Association's present rapid extension in this realm is due to several peculiar features.

All Round Service.—It affects the whole life, physical, mental, spiritual and social, and this means safety in the larger sense. "It is a high-grade, low-cost Young Men's Club, Christian but non-sectarian. It is an Athletic Association that does not use men to promote athletics, but uses athletics to develop men. It is a night school for young men who work by day. It is home for men away from home. It helps men not only to help themselves but to help the other fellow. It is a place for a man to find friends and to make himself a friend to the man who needs a friend. It is the center of community life—a social center in the best sense; it ministers to the health, education and morals of all the people. Its fellowship, club rooms, baths, dormitories, classes and all other practical advantages are open to men of all faiths or no faith." It is not an experiment, but it is the survivor of many experiments.

Adaptability.—It is adapted to all types and conditions. It can and does deal successfully with every group which it has thus far approached. Employees welcome it regardless of creed or condition. Religious differences are not a bar to either membership or the use of its privileges. Men of all creeds and no creeds are enrolled among the half million members in the 2500 Associations in North America. Even among the non-English speaking the Association is working successfully. It is serving the emigrants at European ports and at almost every large port of entry on the Atlantic Coast. There are 400 associations to-day rendering service to the foreigner, from the French Canadian of the Northern Lumber Country to the Mexican "Greaser" of the Southwest.

It is Cooperative.—Employers and employees get together. It works in the zone of agreements—not attempting to adjust disputes but to develop that spirit which, in some cases, prevents disputes from arising; and when disputes have arisen it helps to allay irritation. It helps to create the right state of mind and begets that good-will which finds a basis for the settlement of disputes. Employees always welcome the proposal to establish a Y. M. C. A. in connection with the industry—not every individual, of course, but the group as a whole. There has been no instance of their training down the proposition to establish a modern Association of the approved industrial type, nor has there been a failure as yet to continue the Association after it has been established.

Employers approve the Association increasingly because it affords a tried plan for expressing in a sane, practical and acceptable way something of their sense of responsibility for the best living, working and leisure conditions of employees—a mutually profitable plan that appeals to the best that there is in both employer and employee. It is a real cooperation.

Leadership and Supervision.—No work is undertaken

without a trained leader—a secretary who is representative of the interests of both employer and employee. This, together with the supervision given through the State and International organizations is the best guarantee of success.

There is little ground for the fear sometimes expressed that "The good may be the enemy of the best"—that the Association may interfere with the progress of the various movements for bettering industrial conditions by serving as a salve to the conscience of employers on the one hand or as an anesthetic to workers on the other. It is not installed by employers as an industrial lightning rod to avert strikes, nor is it regarded by the workers as a sop to induce silence. The employers who approve the Association are in the forefront in both thought and action concerning industrial problems and no wage scale is lower and no worker less free because the Y. M. C. A. exists in an industry, but the contrary—at least in some instances. The Association's emphasis upon the highest character standards guarantees this.

I have no desire to overemphasize the importance of agencies like the Y. M. C. A. in promoting good-will and safety in the largest sense and in emphasizing spiritual values. Increasingly, however, this organization is making its power felt not only in the varied industries of our largest cities, but in connection with the cotton, coal, lumber, iron and steel and many special industries.

I have purposely mentioned this work of fostering "mutuality" before indicating a few of the many direct activities in the safety realm. The Association has given lectures to thousands of industrial workers on health, safety and clean living. Last year in Chicago alone 129,000 people, mostly foreign, attended 139 lectures in the public parks. Many of these included motion pictures and stereopticon views on such subjects. Forty thousand foreign men are attending the Association's English classes. This in itself is of course a great safety measure. Many an accident is caused by non-understandings of warnings or danger notices. In hundreds of these classes the safety idea and the larger ideals of right living are included in the instruction. In some railroad shops English is taught by stereopticon views of the safe and unsafe way of performing certain operations, with snappy sentences accompanying the illustrations. A great program of noon-hour recreation, games, athletic leagues, etc., has been promoted. Such activity has sent men back to work with renewed vigor, and an alertness which has surely prevented accidents.

The nation-wide thrift campaign pushed by the Association is in reality a great safety measure. Cartoons, lithographs, movies, stereopticon slides, talks, personal expense accounts, etc., are helping employees not only to save but to spend wisely. This means better home life, better surroundings, health, care of the children, less worry, more lasting habits of self-control. It is needless to indicate the importance of temperance and purity campaigns in relation to this whole question. The special work with boys is helping them to become in every way "safe" men. The inevitable work with women and girls helps make safe homes. Gardening contests and similar features have stimulated an interest in home life. A constructive hobby is good for every man and sends him back to work refreshed. "Socials" make men feel that life is more worth living—and therefore worth being "careful" to enjoy. More than one workman is hurt these days just because the ordinary hopelessness of life has given him the "don't care" attitude. Hundreds of classes in hygiene and first aid meet not only in the Association building but

in shops, mines, construction camps, labor unions, fire-engine houses, police stations, etc.

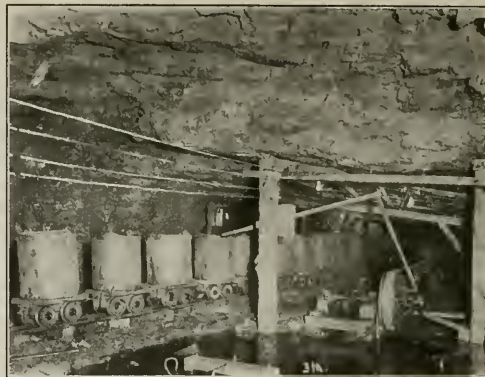
The other day a shop superintendent proudly showed me his safety devices, his hospital equipment and his company doctor. "This is great," I said. "But suppose a man gets hurt at home. Suppose he runs a nail in his foot, fails to use a good antiseptic, gets blood-poisoning and loses a few weeks work." "Gee, I never thought of that," he replied. In other words our shops need not only equipment but definite, sympathetic instruction of foremen and workmen alike. Sometimes I think all our fine safety measures tend to make men careless and relieve them of a sense of personal responsibility. We must teach every employee not only shop safety, but home safety, fundamental health, purity, and character ideals. Then we will really be solving the problem in a larger sense.

"Safety at first, means safety at last." This splendid motto, suggested in a recent number of *Safety Engineering*, applies not only to the shop life but to the whole life. In the final analysis implanting ideals of morality and high standards of character lies at the basis of all real safety. *Right education, recreation and inspiration pays both employer and employee.*

The Zinc Resources of the Joplin-Miami District and the St. Louis Meeting of the A. I. M. E.

To Mr. J. D. Robertson, chairman of the Publicity Committee of the St. Louis Section of the American Institute of Mining Engineers, we are indebted for the six photographs of zinc mining in the Joplin-Miami district herewith reproduced. This district will be visited by the American Institute of Mining Engineers on the last two days of the St. Louis meeting to be held during the week from Oct. 8 to 13, 1917.

Zinc is just now a very important metal. Of course, its use in cartridges and shrapnel brass is just now in the public eye. But its uses after the war are no less important. Brass as an engineering material for electrical machinery, journal bearings, and plumbing fixtures takes fully 50 per cent of the production, and its use in these lines would have been increased in the last few years but for the price. Zinc is used for barbed wire probably more in wartime than in peace. In the composition of paints it is becoming more and more necessary. One of the forms of pigment, lithopone is

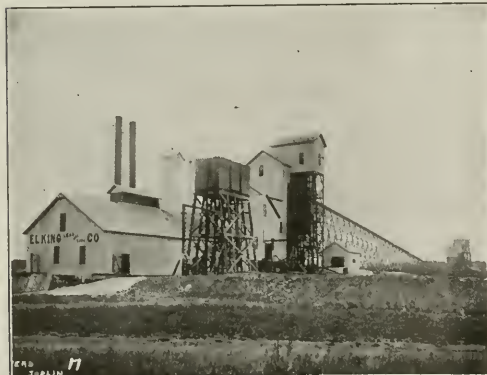


UNDERGROUND HAULAGE IN CONTINENTAL MINE,
WEBB CITY DISTRICT

the base of nearly all interior wall paints as well as of all the sanitary enamels for bathrooms and bathtubs, and is now in great demand. Zinc oxide is also increasing in use for paint and for manufacture of linoleum.

When it is realized that this district of Missouri, Oklahoma, Kansas and Arkansas produces now over one-third of the zinc ore of the world, it is at once seen that a meeting where the geology, mining, concentration and smelting of this ore will be considered, and trips to Joplin, Mo., and Miami, Okla., made, as well as to some of the modern smelters where the sulphurous gases are turned into sulphuric acid, will not only be interesting, but at this time important. There will be shown the immense low-grade mines of Joplin and Webb City, Mo. Some mines produce ores with only 1 per cent of zinc. Likewise, there will be also shown the high-grade mines of Miami, Oklahoma, where some of the mines are producing ore that nets 20 per cent zinc.

The problems connected with the concentration are not so simple as they once looked. It is easy to get out the first 80 per cent of the value, but the treatment of the slimes is as yet a problem. Much is hoped for in the comparatively new process of flotation. The precise place of the new electrolytic process of recovering zinc is not yet known. It has proved successful in Montana, and may be equally valuable in this district. It is hoped that the problem of getting the last few per cent of zinc out of the ore will be the subject of an



TRAMWAY CONNECTING MILL AND FIELD SHAFT,
WEBB CITY DISTRICT



ZINC CONCENTRATES (BLUE GOOSE)



SOFT GROUND MINING, JOPLIN DISTRICT



CORNFIELD MILL, CARDIN, OKLA.

extended and profitable discussion at the St. Louis meeting.

The outline of the general arrangement of the St. Louis meeting of the American Institute of Mining Engineers, as planned at present, is as follows:

Monday, Oct. 8:

Morning—Technical session.

Afternoon—Boat ride to Herculaneum, Mo.

Evening—Dinner on boat and social evening.

Tuesday, Oct. 9:

Morning—Visits to plants in the vicinity of St. Louis and coal mines in Illinois.

Afternoon—Technical session.

Evening—Banquet.

Wednesday, Oct. 10:

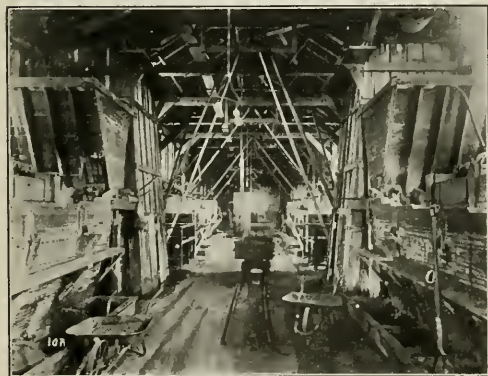
Trip by special train to the Southeast Missouri lead district. (Illustrations and statistical data on this district were given in our issue of May 1, 1917, on pages 472 and 473.)

Thursday, Oct. 11:

Morning—Visits to plants in the vicinity of St. Louis.

Afternoon—Technical session.

Evening—Leave by special train for Joplin and Tulsa.



JIG ROOM IN ZINC MILL, JOPLIN DISTRICT

Friday, Oct. 12, and Saturday, Oct. 13:

A choice of one of three possibilities, noted below, will be given:

1. Two days in the Tulsa area, including trips to an oil pool, refineries, gasoline plants, and a technical session.
2. Two days in the Joplin-Miami district, including surface and underground trips, visit to the Pittsburg, Kans., coal field, and a technical session.
3. One day in the Joplin-Miami district and one day in the Tulsa area.

One Billion Gallons of Synthetic Gasoline in 1916*

By Walter F. Rittman

The market value of synthetic gasoline produced by cracking in the United States during 1917 will be sufficient to supply the Navy with ten superdreadnaughts. In other words, one-fifth of the 3,000,000,000 gal. to be produced will be made by cracking.

By July 1 of the present year there will be in operation in the United States 4,000,000 automobiles. Financial men, in considering the investment value of motor stocks, have for several years been dwelling upon the saturation point, but, despite this consideration, the demand for machines still keeps well ahead of the 40 per cent average yearly increase of past years. When the saturation point will be reached nobody knows. Responsible and successful automobile men maintain that the present increase in rate of production will keep up for years, and that after the present high prices of materials the price of cars can be so reduced that every family having an income over \$1,000 may own a car. On this basis, the United States will have in the neighborhood of 10,000,000 automobiles, two and one-half times the present number. Assuming an annual life of five years per machine, 10,000,000 cars means an annual replacement number equal to 2,000,000; i.e., our present rate of production. When one questions the correctness of the opinion of the automobile man who suggests the above figures, the answer is made that every prediction which the automobile man has heretofore made has been too conservative. An important consideration is the greatly increasing number of motor trucks necessary to replace the shortage in horses. As to

*A paper read at the Kansas City meeting of the American Chemical Society, April, 1917.

the influence on this industry of the United States' entrance into the European war time will tell.

Only the steel, lumber and clothing industries exceed the automobile business in importance to-day. Detroit, the center of this new industry, has risen as a manufacturing center from sixteenth place in 1900 to sixth place in 1914. In the United States over 500 factories are to-day engaged in making different types of automobiles, and new companies of varying stability are announced each week. As a side light, it is interesting to observe the approximate annual upkeep involved in America's automobile bill which is as follows:

\$500,000,000—Gasoline,
500,000,000—Tires,
300,000,000—Accessories,
150,000,000—Garage Hire,
150,000,000—Repairs.

The number of automobiles in use in this country on Jan. 1 over the period of the past fifteen years is as follows:

Year.	Number of cars.
1905.....	85,000
1910.....	400,000
1911.....	600,000
1912.....	677,000
1913.....	1,010,483
1914.....	1,253,875
1915.....	1,754,570
1916.....	2,225,000
1917.....	3,250,000
1918.....	4,750,000

However, gasoline requirements are not limited to the above automobiles, but, in addition, tremendous quantities are exported, are used in motor boats, motorcycles, farm engines, chemical manufacture, cleaning establishments, etc., etc. The requirements per machine per annum vary with different users, some using on an average of less than a gallon a day, whereas, the public vehicle often uses as high as 10 gal. a day. Statistics would indicate that the average consumption per car per annum approaches 500 gal.

Of the various problems confronting the automobile industry, the motor fuel problem of the future has loomed up as the most important, but it would seem that this problem will temporarily, at least, be solved. Much discussion and attention is paid to the use of gasoline substitutes, such as alcohol, benzol, gasoline from natural gas, electricity, etc. All of these materials are very valuable sources of power, and the extent of their use is entirely a question of quantity produced, and price. Alcohol is commercial when gasoline exceeds 35 cents per gallon. This price, however, is based on ante-war prices, as every one realizes that the present price of alcohol makes it prohibitive. Benzol, when mixed with gasoline, makes a superior type of motor fuel, and here again it is entirely a question of the supply available. The figures of the best informed people in this field indicate a supply of benzol and light oils available equal to 100,000,000 gal., which, it is observed, will fulfill less than 10 per cent of our motor fuel requirements, even though none of the benzol and similar materials were used for explosives and other chemical purposes.

Casing-head gasoline (gasoline from natural gas) is an item of considerable importance because it is so volatile and has such wide explosive limits that it can be blended with naphthas and thereby make available for motor use materials which were not available. The production of this material has been as follows, but this production, it may be remarked, will hardly supply more than one-tenth of our fuel requirements:

1911.....	7,425,839 gal.
1912.....	12,081,179 "
1913.....	24,060,817 "
1914.....	42,652,632 "
1915.....	65,364,665 "
1916.....	125,000,000 "
1917.....	200,000,000 "

Much is heard of the kerosene carburetor, and the patent office holds thousands of carburetor patents. Professor Lucke of Columbia University rightly believes that in the development of a commercial kerosene carburetor it will not be a new invention, but a matter of a design utilizing parts from various patents or designs already developed that will solve the problem. Practically no consideration has been paid to what is perhaps the most important factor militating against the use of kerosene; i.e. the question of explosive limits. This will be discussed later. The carburetors already invented surely embody all possible principles, so it would seem that from this time forward the problem is one of a design wherein ideas from different carburetors are brought together in a new form. A partial way out of the difficulty may be by reversion to the steam type of automobile in which heavier oil is used to generate the steam.

The increase in the crude oil production of the United States during a period corresponding to the automobile figures previously given, is shown as follows in barrels of 42 gal.:

1905.....	134,717,580
1910.....	209,557,248
1911.....	220,449,391
1912.....	222,935,044
1913.....	248,446,230
1914.....	265,762,535
1915.....	281,104,104
1916.....	292,300,000

The production of gasoline, also in barrels of 42 gal. has been:

1904.....	6,920,000
1909.....	12,900,000
1914.....	34,915,000
1915.....	41,600,000
1916.....	54,760,000
Estimated 1917.....	70,000,000

From these figures it will be observed that during the period from 1910 to 1917, when the number of automobiles increased eight fold, crude oil production grew but a little over one-third, and gasoline production increased four times, an order of magnitude comparable with the growth in production of automobiles. This increased production of gasoline from a relatively constant quantity of crude oil is obviously the result: First, of taking a larger portion of motor fuel from the crude oil and calling it gasoline; and, second, of producing gasoline from heavier oils by cracking.

The question naturally arises as to how much further into crude oil the petroleum man can cut in order to increase the supply of motor fuel. We have all observed the Baume gravity of gasoline decrease from the seventies to the fifties, which means an increase in the specific gravity from 0.700 to 0.778. But practical motor men to-day believe that, with the present automobile carburetor and engine, gasoline containing heavier portions of the crude oil below 50 deg. Baume does not work efficiently.

Scientific explanation of the fact can be found in a consideration of the explosive limits of various hydrocarbons. For every mixture of hydrocarbons and air, as is produced in the carburetor, there is a proportion below which the mixture contains too small a

percentage of hydrocarbons to explode. There is also an upper limit above which the mixture contains too large a percentage of hydrocarbons to explode. Between these two limits is the desired range in which the proper explosive mixture is formed. For instance, a mixture of natural gas and air containing below 5 per cent of gas will not explode; also a mixture containing more than 11.5 per cent of gas will not explode. Hence the explosive limits for mixtures of natural gas and air are between 5 per cent and 11.5 per cent of gas. Similarly, the explosive limits for mixtures of gasoline vapor and air lie approximately between 1 and 4 10 per cent and 6 per cent of gasoline vapor.

When the size and weight of petroleum molecules increase, the boiling point is raised. In other words, the higher the molecular weight, the heavier and less volatile is the material. Furthermore, as the volatility of these hydrocarbons decreases, the limits for their explosive mixtures with air, below which nothing happens and above which there is a burning rather than an explosion, come closer and closer together.

Consequently, as we go from lighter petroleum products, such as gasoline, to heavier petroleum products, such as kerosene, and up to materials boiling above 400 deg. F., the range for explosive mixtures of air and heavy hydrocarbon vapors becomes more and more narrow, until a point is reached where there is a great difficulty in adjusting the mechanical parts of the carburetor so that they deliver the proper explosive mixture. For example, suppose a mixture of 5 per cent hydrocarbon vapor and 95 per cent of air is the only possible explosive mixture for the vapors of a certain substance, how difficult, if not impossible, it would be to adjust a carburetor to deliver accurately and continuously that exact mixture.

The result then is that when this heavy material, with narrow explosive limits, is used for fuel, there is slow burning rather than explosion, and only a part of the combustion occurs in the cylinder where it can be utilized. Therefore, it is questionable whether an efficient carburetor for heavy kerosene can be devised.

Other suggested solutions of the motor fuel problem involve the use of oil derived from coal, shale, peat and lignite. These will be immensely important sources of liquid fuel in the more remote future. Passing over the large supply of light oil possible from coal now burned without coking, which may amount to as much as a billion gallons of fuel per annum, there are immense shale deposits in America, containing a volume of oil many times greater than that now known. Here the problem of obtaining motor spirits from the oil will arise again and the solution of it, as of our present problem, will necessitate cracking processes.

Then, as now, the demand for motor spirits will run ahead of the supply obtainable by straight distillation; and the logical solution of our present motor fuel problem will be the logical solution in future problems. The fundamental proposition is that when the demand for gasoline doubles or trebles, while the amount of petroleum remains nearly constant, we must make more gasoline from a given volume of crude oil. The best evidence that this proposition furnishes the answer to our problem is the fact that cracking processes are now solving the problem. In other words, since 20 per cent of our gasoline is now being made by cracking, the price of gasoline would of necessity be much higher without this increased supply.

The chemical phenomena involved in the cracking

of heavy oils into lower boiling oils have been discussed in considerable detail in Bulletin No. 114, United States Bureau of Mines. Broadly speaking, and without consideration of relative merits, cracking processes may be classified under the five heads:

- (a) Liquid condition processes wherein oil is cracked as a liquid;
- (b) Gaseous condition processes wherein oil is cracked as a gas;
- (c) Processes wherein cracking is aided through the use of catalyzers;
- (d) Processes wherein the oil is mixed with steam, hydrogen, or other materials;
- (e) Combinations of the above four methods.

The object of the present paper is not to discuss the technical nor the research side of cracking, but to indicate how real is this industrial operation to-day. During the present year, 1917, approximately 600,000,000 gal. of cracked gasoline is being produced in the United States. It is estimated by competent authorities that the production of cracked gasoline in 1918 will be 1,000,000,000 gal., and that by 1920 more gasoline will be produced by cracking than by all other methods. Many people have been disappointed because cracking processes have not reduced the price of gasoline materially, but they have failed to consider their tremendous benefit in keeping the price of gasoline from going 10 cents a gallon higher. Seven thousand automobiles a day require a cumulative supply of motor fuels. Our crude oil production is not increasing. Kerosene carburetors as yet are not a factor. The entire load is falling on the shoulders of cracked gasoline, and cracked gasoline promises to make light of its load.

The Vosmaer Phenomenon*

By William C. Moore

A number of years ago a patent was taken out by A. Vosmaer, of Haarlem, Holland, for the production of light by means of a discharge between nickel wires serving as the secondary terminals of an induction coil. About the time of the expiration of this patent, a description of the phenomena involved was written by Vosmaer and published in the June, 1914, number of *Metallurgical and Chemical Engineering*.¹ In brief, when the wires used are of the correct size for the induction coil to which they are connected, and the distance between the ends of the wires is properly adjusted, the cathode wire fuses at the end, forming a small globule, which glows with high intrinsic brilliancy.

Through the kindness of Mr. David H. Browne, of the International Nickel Company, this laboratory received a supply of various sizes of nickel wire, with which Vosmaer's experiments were repeated and extended. For convenience, the results are designated as the "Vosmaer phenomenon."

With a coil giving a normal spark 3 in. (7.5 cm.) in length, the results noted in Table I were obtained.

On increasing the distance between the electrodes the light from the cathode became less brilliant, and finally went over into a nickel spark.

A 0.4 m.m. cathode and a 0.6 m.m. anode of nickel wire were now set up in a long glass tube closed at the end with rubber stoppers, the apparatus being so arranged that the air could be exhausted and other gases admitted. On exhausting the air till the pressure

*A paper read at the Detroit meeting of the American Electrochemical Society, May, 1917.

¹Eng. patent 21,877 (1899).

²Vol. 12, p. 377.

within the tube was 10 m.m. of mercury, no sign of the Vosmaer phenomenon was noted.

Instead, there was a violet glow over the entire length of both wires. On admitting air, the Vosmaer light appeared; the nickel cathode fused, formed a ball and apparently oxidized, and then began to glow. Again, an intensely hot spot was noted on the anode. On exhausting the tube while the coil was running,

TABLE I

Kind and Size of Wire (Diameter in m.m.)		Anode Phenomenon	Cathode Phenomenon
Ni + 0.8	Ni 0.6	—	End melted formed ball; glowed intensely.
Ni 0.6	Ni 0.8	—	No glow—(too large?)
Ni 0.4	Ni 0.4	—	Oxidized, formed ball, glowed. Reversing current caused other electrode to glow.
Ni 0.4	Pt —	—	Pt, melted; ball formed; glow less intense than with Ni.
Ni 0.4	Small Fe	—	Ball formed, larger than with Ni. Glow less intense than with Ni.
Ni 0.4	C from lead pencil	Intensely hot spot on anode	C glows.
C	Ni 0.4	Intensely hot spot on anode	Vosmaer phenomenon.

the Vosmaer light grew less brilliant and completely disappeared at 50 m.m. pressure.

Before this, however, a violet glow began at the ends and gradually extended back along the wires.

Readmission of air brought about a reappearance of the Vosmaer phenomenon; increasing the pressure above normal, however, seemed to have no effect.

A series of experiments was now tried with different gases in the tube, using a 0.4 m.m. nickel wire cathode against a 0.6 m.m. nickel wire anode.

When natural gas was used in the tube, the discharge decomposed the gas; at first, the spark was very luminous. The carbon deposit collected first on the cathode; later on the anode; finally, a carbon bridge was formed which short-circuited the spark gap. This carbon was finely divided; with a long gap, carbon was deposited on the walls of the tube; the spark then jumped to the tube wall. There was no indication of the Vosmaer phenomenon.

With hydrogen chloride in the tube, the cathode was rapidly attacked and was soon destroyed, with the resultant formation of nickel chloride, in a very finely divided condition. There was some indication of the Vosmaer phenomenon.

Nitrogen, prepared from ammonium chloride and sodium nitrite and dried by passing through sulphuric acid, was passed into the tube. On starting the induction coil, the Vosmaer light developed as usual at the cathode; the cathode, however, was rapidly attacked. The spark proper was greenish. The anode showed the Vosmaer phenomenon at first, but this was prevented by speeding up the interrupter. The nickel at the cathode had the appearance of boiling.

On analyzing the above results, it seems that the following phenomena take place, in the order named, when the wires are of proper size and the gap is of the proper length:

1. On turning on the current the cathode becomes intensely hot at its extreme end, and soon melts.
2. The surface tension of the molten nickel is sufficient to draw the molten material up into a ball.
3. While (1) and (2) are taking place the outer portion of the fused mass becomes oxidized. This oxide adheres very firmly to the nickel; as it apparently has a higher melting point than nickel (1450 deg. C.),³ the nickel is protected from further attack and so is not used up. An equilibrium temperature is therefore soon reached; the facts that the ball when

the energy is liberated is so much larger than the wire, and that the heat conductivity of nickel decreases very rapidly with the temperature⁴ cause this equilibrium temperature to attain a high value. The high emissivity of the nickel oxide layer⁵ explains the high intrinsic brilliancy of the little ball.

On the other hand, if the nickel compound formed, does not adhere to the nickel, the nickel is attacked, as occurred when the experiment was run in hydrogen chloride; if a low melting compound is formed, as with nitrogen, the same thing occurs.

On the electrical side, the conditions for the proper development of the Vosmaer light are not less interesting than on the chemical. In the article above referred to, Vosmaer calls attention to the fact that the discharge we are discussing could be called a high-tension arc discharge. The recent paper of Prof. W. G. Cady⁶ on "Unstable States in Arc and Glow" contains a discussion of the transition from the glow to the arc discharge, which would seem to apply here. The "Vosmaer phenomenon" is apparently a transition from the glow to the arc; the energy liberated at the cathode raises its temperature so that thermal ionization sets in. The ions so liberated ionize the air by impact; the positive particles so produced bombard the cathode, raising its temperature finally to what I have designated above as the "equilibrium temperature." In line with this explanation, the disappearance of the Vosmaer light when the pressure is reduced is easily understood. The mean free path of the ions becomes greater; so much ionization is therefore not produced in the immediate vicinity of the cathode; as many positive particles cannot reach the cathode as formerly and no light is produced.

The induction coil used required about 6 amperes at 6 volts. While no candlepower measurements were made, the total light emitted from the glowing cathode was less than that given by an ordinary 3-volt flashlight. It is thus seen that this glowing cathode is out of the question as an efficient light source.

Dinner to M. C. Whitaker and F. J.

Metzger

At the Chemists' Club on Wednesday evening, April 25, the Chemical Engineering Society of Columbia University held a dinner, at which former Professors M. C. Whitaker and F. J. Metzger were the guests of honor. The society presented to each of them a silver desk clock as a token of appreciation and gratitude for their work in building up the School of Chemical Engineering at Columbia, of which Professor Whitaker was the head.

Mr. M. Landau, president of the society, introduced Dr. C. F. Chandler, the dean of the chemical profession in America, who acted as toastmaster. Dr. Whitaker, discussing the "industrial situation," told about the problems which manufacturers must meet, due to the activity of enemy agents. Dr. Metzger gave a short talk on "chemical engineering." Mr. A. F. Smithers and Mr. A. A. Haldenstein, seniors, both talked on Columbia.

Prof. D. D. Jackson, acting head of the School of Chemical Engineering, discussed "preparedness for the chemical engineer." Dr. J. Teeple gave the diners some excellent advice, when he responded to the toast, "things to remember." Prof. M. T. Bogert, chairman of the National Research Council, spoke on "the chemist in the present crisis." Professors Tucker and Neish each spoke in appreciation of Doctors Whitaker and Metzger. Much credit is due the dinner committee, of which Mr. E. C. Brueckmann was chairman.

⁴Angell, Phys. Rev., 33, 421 (1911).

⁵Burgess & Foote; J. Wash. Acad., 4, 279-80 (1914).

⁶Met. & Chem. Eng., 13, 866 (1915); Trans. Am. El. Chem. Soc., 29 (1916).

³Bureau of Standards, Circular No. 7 (1916).

Modern Concentration of Colorado Tungsten Ores

By S. Fischer, Jr.

Much has been said both for and against the tungsten milling practice of the Nederland district; however, nothing but praise and admiration remain from a visit to the recently erected tungsten mills. The rather unsparing criticisms expressed by various writers in regard to the bad engineering features involved in the construction of the older mills were justified, but might have been less severe if the fact had been considered that Boulder County was primarily an unsuccessful gold and silver district. For many years the tungsten concentrates were mistaken for magnetite, and discarded. Then when engineers of the Primos Chemical Co. disclosed the value of the wasted material the whole situation was altered. Old gold and silver mills were employed as concentrators for tungsten ores. The machinery used originally for the concentration of gold ores had to perform the work for the concentration of the tungsten ores. Very little was known at that time concerning the nature of tungsten ores, or what methods of concentration were best suited for the ore. Under the circumstances it is not surprising that the first mills installed showed errors in construction and that the efficiency of their operation was low.

Few if any ore-dressing methods have ever developed so rapidly as those for the Colorado tungsten ores. As recently as March, 1916, there was really only one up-to-date tungsten mill, and this has since undergone some improvements. The increased demand for tungsten in the Eastern market created a boom in the district, and it is mainly due to this fact that some half a dozen new mills have been installed throughout the locality. These, with few exceptions, may be classed as typical concentrators for ferberite ores. Only the new features introduced in the older mills will be discussed, as the detailed operations of these plants have already been treated in earlier articles. The new mills of the district will be covered as thoroughly as possible.

General Line of Improvements

The main error made in the older milling practice was in fine crushing at too early a stage. This resulted in the loss of much of the values in the slimes. The fundamental principles involved in modern practice are to grade the product according to size as it passes through the mill and to eliminate as much of the values from the various sizes as possible before subjecting the ore to fine grinding. These two factors aid in several directions. They give a higher recovery and reduce the area of the rag plant required for the treatment of the slimes.

The substitution of rolls for the stamps and the installation of jigs for collecting the coarse concentrates are the new features along the lines mentioned. Another improvement practised in some instances is the dewatering of the overflow product from the Akins classifier before passing it over the slime tables. This last factor aids in the saving of water, which at times is of considerable importance, and also makes it possible to handle the pulp more efficiently. Fig. 1 represents the flow sheet of a typical modern Colorado tungsten ore concentrating mill.

STAMPS VERSUS ROLLS

Most mill superintendents of the district concede that stamps are unsatisfactory for the milling of ferberite ores, since they give too large a percentage of slimes at an undesirable time in the stage of the concentration, thus creating losses. With the aid of impact screens,

on the other hand, rolls give a product which may then be sent to a jig, where the coarse concentrates are collected previous to ball-mill treatment.

THE HARZ AND THE RICHARDS PULSATING JIG

Jigging of the coarser materials preparatory to fine grinding is considered essential for the successful operation of a Colorado tungsten ore concentrator. The question is what jig should be used. The pros and cons for each type of jig have been closely investigated, and the conclusions drawn by most engineers are that for present conditions, in which most of the ore handled is of a low-grade nature, fluctuating in its composition, the Harz jig, which has better adjustment in respect to the accumulations on the screen, is undoubtedly to be preferred. With the Harz jig it is possible to retain a large amount of ore on the screen over a long period of time; whereas the Richards apparatus does not permit this condition.

Where rich ores are milled, however, as at the Wolf Tongue mill, the Richards type of jig works very satisfactorily. It may be said with certainty that the majority of the up-to-date mills use the Harz in preference to the Richards jig.

DEISTER AND MONELL SLIMERS

The probable explanation for the presence of the Monell slimers in the district is that these slimers were used in the gold and silver mills previous to the tungsten discovery. While these tables worked satisfactorily on free-milling gold and silver ores, their use in the dressing of ferberite ores is impractical. The very fine slimes produced in the tungsten mill cake on the Monell slimer and give a very low recovery. For this reason the Deister table, which gives a very suitable separation of the values from the slimed gangue, is found in practically all the new mills.

The above mentioned apparatus are of such paramount importance in the dressing of ferberite ores that it was considered essential to treat them separately. The other types of machines used will be discussed under the head of each individual mill.

The Wolf Tongue Mining Company's Mill

Since the Wolf Tongue mill is one of the oldest mills in the district having undergone the various developments in connection with the tungsten ore-dressing methods, the present plant seems somewhat crowded. In spite of being handicapped by lack of space this mill has the reputation of being the best concentrator for ores containing more than 10 per cent tungstic acid (WO_3). About 90 per cent of all the ore treated is from the company's own property.

The ore undergoes the following steps in concentration: All ores received at the mill are first weighed, and then placed in bins. Ores containing more than 40 per cent tungstic acid are passed through a sampling crusher, and from here go to a sample cutter which takes a 10 per cent sample. The sample thus obtained is treated similarly to the low-grade samples taken in the mill, as will be explained below. If this type of ore is of "shipping grade" it is drawn from the bins, sacked, and shipped without milling.

Ore of less than 40 per cent tungstic acid goes from the bins to a Blake crusher. From this crusher the material passes through rolls into the No. 1 elevator, which raises the product to a sample cutter. The sample taken, 10 per cent of the total, is conveyed to a No. 1 sample bin. If such a sample is more than 300 lb. in weight it is recut and a second 10 per cent sample is obtained, which goes to a No. 2 sample bin. It is then reduced by "splits" until a final sample of 1 lb. is ob-

classifier, the plus 30-mesh going to the No. 1 Card table, while the minus 30-mesh product goes to a 50-mesh Bunker Hill classifier. The plus 50-mesh passes onto Card table No. 2, while the minus 50-mesh ore continues to a 100-mesh Bunker Hill classifier; the plus 100-mesh product proceeds to Card table No. 3, while the minus 100-mesh material is treated on Card table No. 4. The overflow from the hydraulic is conducted to the slime distribution box, and from here is passed on to Card tables No. 4 and No. 5.

All tables make a —60 per cent and a 20 per cent tungstic acid product, and a regrind sand; this latter passes to the No. 4 battery or to the ball mill. The regrinding battery has a 30-mesh screen. The ball mill material goes to a Richards launder jig, from that point to a hydraulic. The jig gives a material of 50 per cent tungstic acid or better. The regrind battery product passes over Wilfley tables. The tails from the No. 1, No. 2 and No. 3 Cards are pumped to the "rag plant" by means of a centrifugal pump; while those of the No. 4 and No. 5 Cards and the Wilfleys pass onto Monell slimers. These slimers yield two products, namely, concentrates averaging 30 per cent tungstic acid, and tails, the latter being pumped to the "rag plant" by a centrifugal pump.

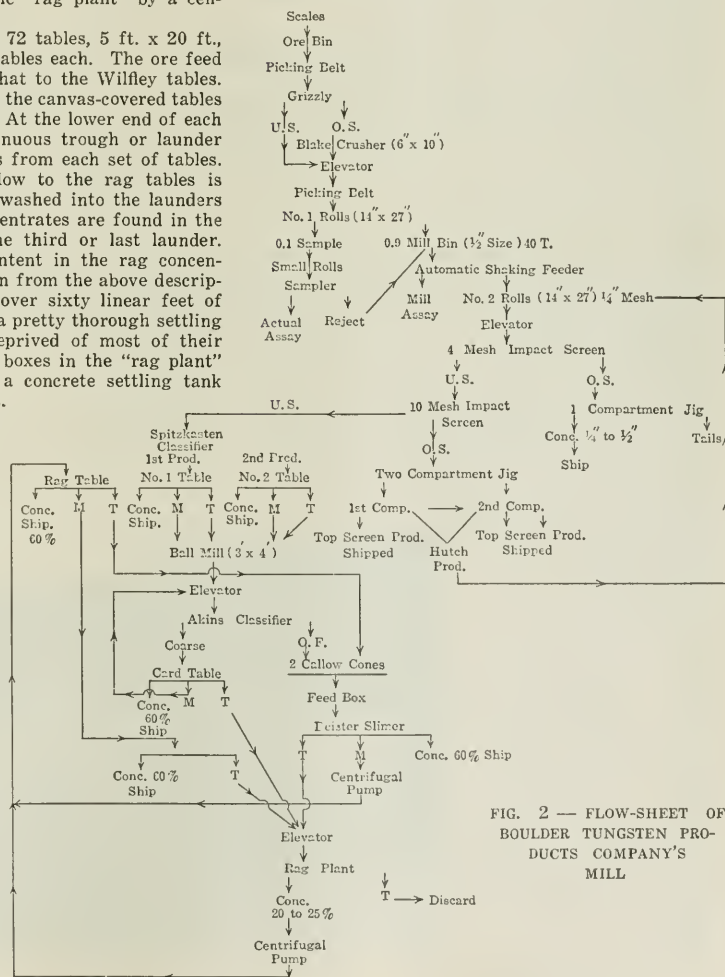
The "rag plant" consists of 72 tables, 5 ft. x 20 ft., arranged in three tiers of 24 tables each. The ore feed to these tables is similar as that to the Wilfley tables. The water current flowing over the canvas-covered tables should show a rolling motion. At the lower end of each tier of tables there is a continuous trough or launder which collects the concentrates from each set of tables. From time to time the ore-flow to the rag tables is stopped, and the concentrates washed into the launders with a hose. The richest concentrates are found in the top launder, the lowest in the third or last launder. The average tungstic acid content in the rag concentrates is 30 per cent. It is seen from the above description that all the slimes pass over sixty linear feet of canvas, giving ample time for a pretty thorough settling of the values. The slimes deprived of most of their values are discarded. All ore boxes in the "rag plant" are connected by pipes with a concrete settling tank which serves to catch the fines.

Some special features are worthy of mention. All bins and elevators are connected to a dust fan, which removes the dust in the machinery to a cyclone dust collector. The heavier particles drop and are collected, while the fine dust passes through a special machine, the design of this machine being borrowed from the flour mill. It consists of a hollow horizontal trunnion, around which are placed supports for "stockings" made of wool. These stockings are ranged radially along the whole length of the trunnion, and serve the same purpose as the bags in a bag collector, namely as a filter. The trunnion rotates slowly around its horizontal axis, and a knocker is so arranged as to tap three rows of stockings at a time. This loosens the material adhering to

the stockings, which is then collected. When a sufficient amount of dust has accumulated from both machines it is sent through the mill as if it were ore.

The claim is made that the stocking collector for the fines adds a considerable saving to the mill operation. All regrind sands may be cut out of the mill from any table when deemed necessary. All the ore boxes in the plant have overflow pipes, which go to settling tanks to catch the fines. There is also one high-speed Hendrie & Bolthoff Card table, which serves to re-treat such ores, where it is necessary to raise the grade. For emergency purposes the plant is equipped with one set of two two-compartment Harz jigs (18 in. x 32 in.).

The full capacity of the plant is 75 tons per day, but at present it is treating only 40 to 50 tons daily. The grade of ore treated varies from 0 to 40 per cent tungstic acid. The latter figure, however, is far beyond the average mill run at the present time, as ores of such high tungstic acid content are becoming more and more scarce. The average mill run of the Wolf Tongue mill is probably in the vicinity of 10 per cent. The water rights of the mill are such that a lack of water is out of question. The plant is operated by electricity, which at



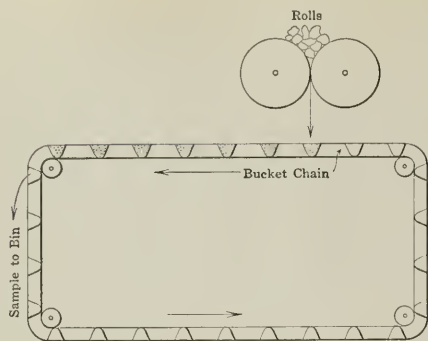


FIG. 3—SAMPLING DEVICE AT THE MILL OF THE BOULDER TUNGSTEN PRODUCTS COMPANY

the present time is bought from the Colorado Power Co. The mill, however, is equipped with its own power unit, so that it can supply its own electricity if conditions demand it.

Some technical data may prove of value. The Wolf Tongue is able to produce anywhere from 500 lb. to three tons of concentrates per day, depending upon the richness and amount of ore treated. In general it may be said that all mills endeavor to produce a 60 per cent concentrate; this product calls for the highest prices in the market; higher concentration products bring no higher prices.

The concentrates at the Wolf Tongue mill run as follows: The first jig concentrates contain over 55 per cent tungstic acid; those of the first tables and slimers contain over 60 per cent; the second jig product, as well as the second concentrates, run approximately 20 per cent; the concentrates from the Monell slimers contain between 30 per cent and 40 per cent tungstic acid, and the products obtained from the rag plant average 30 per cent of the values.

Ores containing over 50 per cent tungstic acid are ground and then sacked and shipped without further treatment. The discarded slimes contain from 0.25 to 0.5 per cent tungstic acid.

The concentrates produced at this plant are shipped to the Stirling Steel Co. of Latrobe, Pa. This firm is the parent company of the Wolf Tongue Mining Co. The products manufactured by the Stirling Steel Co. are sold to the Washington Steel & Ordnance Co. of Washington, D. C.

Mill of the Boulder Tungsten Products Company

The flow-sheet of this mill, which is situated at Tungsten, Col. (Stevens Camp), is given in Fig. 2. Since the last description in METALLURGICAL & CHEMICAL ENGINEERING, Vol. XIV, p. 301 (March 15, 1916) the mill has undergone many changes. Not only has a rag plant been added to the equipment, but various new steps in the concentration proper have been installed.

The mill handles custom ores of a low-grade charac-

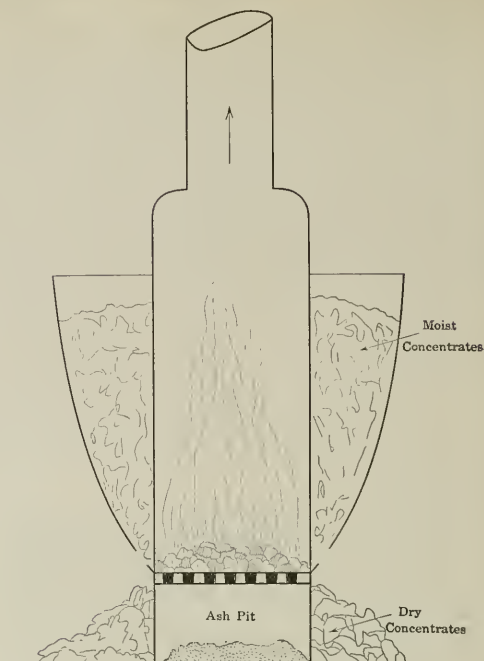


FIG. 4—CONCENTRATE DRYER

ter, usually running below 5 per cent in tungstic acid. The capacity of the plant is from 25 to 30 tons a day, but at present a lower tonnage is handled. The aim of the plant is to have all concentrates containing 60 per cent tungstic acid. During the time of the tungsten boom, the mill produced from 1200 lb. to 1.5 tons of concentrates per day.

Since much of the ore treated at this mill is moist, Vezin samplers proved unsatisfactory, as they clogged very easily. The sampler devised to take the place of the Vezins which is generally used in the district consists of buckets moving on chains, the cut being taken parallel to the rolls. The design of such a sampler is



FIG. 5—TUNGSTEN (STEVENS CAMP) BOULDER CAÑON, COLO.

shown diagrammatically in Fig. 3. Two of these samplers are used, one after the No. 1 rolls, which takes a 0.1 cut of the total ore passing through the mill. The sample then passes through a small set of rolls to a second sampler of the same type, which again takes a 0.1 cut; this is the actual assay sample, while the rejects go to the mill bin as shown in the flow-sheet. The sample taken from the mill bin through the automatic shaking feeder indicates what is actually milled during each day even though there be some ore left in the mill bin from the previous day.

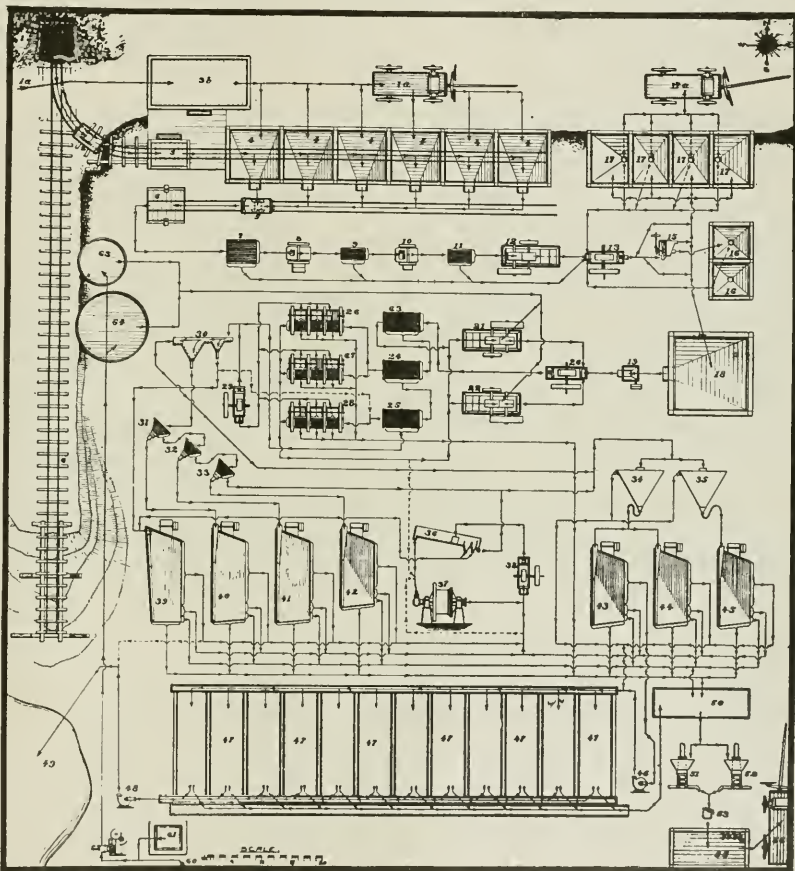
The No. 1, No. 2 and the Card table have a Wilfley top and a Card motion. The rag table, which is a straight Wilfley, has been installed to treat the "rag plant" concentrates and bring them up to a 60 per cent product. An interesting feature in the plant is the installation of a Frue vanner to handle the middlings from the rag table. The Frue vanner concentrates are clean and run 60 per cent tungstic acid. The tails from this unit go to the elevator back to the rag plant. The Frue vanner has proven a saving item.

The dryer universally used at the Nederland mills consists of an ordinary stove with a grate for the fuel, which is surrounded by a jacket perforated at the bottom, shown in Fig. 4. The wet concentrates are charged into these jackets and come into contact with the hot stove. When dry the concentrates are discharged through the perforations in the jacket, allowed to cool and then sacked ready for shipment.

The concentrates are sacked as follows: The Vanner, Deister and rag table concentrates are packed in sacks weighing 120 lb.; the No. 1 and No. 2

are sacked in 125-lb. batches and the jig concentrates are put into sacks in 110-lb. lots.

The reason why such an endeavor is made to produce 60 per cent concentrates is that the company sells its product directly to the buyer, and does not ship it to concerns connected with the mill as various other mills in the district do. To obtain the maximum financial returns the product must be of the mentioned grade as the purchases are made on the basis of 60 per cent.



LEGENDA

- | | | |
|---|--|-------------------------------|
| 1 Vasco No. 5 tunnel. | 18 50-ton mill bin. | 36 36" Atkins classifier. |
| 2 Mine car. | 19 Plunger feeder. | 37 4 ft. x 3 ft. ball mill. |
| 3 Track scale. | 20 12" bucket elevator. | 38 8" bucket elevator. |
| 3a Custom ore wagon. | 21 27x14 McFarlane parallel rolls. | 39 Wilfley concentrator. |
| 3b Wagon scale. | 22 27x14 McFarlane parallel rolls. | 40 Card concentrator. |
| 4 Receiving bins. | 23 36"x72" revolving screen, 4 mesh. | 41 Card concentrator. |
| 5 Ore push cart. | 24 36"x72" revolving screen, 10 mesh. | 42 Card slime concentrator. |
| 6 5'x6' platform elevator. | 25 36"x72" revolving screen, 20 mesh. | 43 Card slime concentrator. |
| 7 Grizzly, 1/4" spaces. | 26 Harz 3-compartment jig bed, 10 mesh. | 44 Card slime concentrator. |
| 8 11x7 Samson crusher. | 27 Harz 3-compartment jig bed, 10 mesh. | 45 Card slime concentrator. |
| 9 Grizzly, 1/4" spaces. | 28 Harz 3-compartment jig bed, 30 mesh. | 46 Centrifugal pump. |
| 10 10x9 universal crusher. | 29 8" bucket elevator. | 47 Canvas tables. |
| 11 Stationary screen, 1/4" square openings. | 30 Flood hydraulic classifiers. | 48 Centrifugal pump. |
| 12 27x14 McFarlane parallel rolls. | 31 Bunker Hill screen, 30 mesh. | 49 Impounding basin. |
| 13 10" bucket elevator. | 32 Bunker Hill screen, 50 mesh. | 50 Drainage bins. |
| 15 36" dia. Vezin sampler, 1 scoop, cuts 1-20 part. | 33 Bunker Hill screen, 100 mesh. | 51 Concentrates drying stove. |
| 16 Sample bins. | 34 8-ft. Callow dewatering tank. | 52 Concentrates drying stove. |
| 17 Settlement bins. | 35 8-ft. Callow dewatering tank. | 53 Concentrates sacking. |
| 17a Sampled ores removed from mill. | 62 Triplex geared power pump. | 55 Concentrates storage. |
| 61 Mill water clarifying basin. | 63 & 64 Mill and fire service tanks. | 56 Concentrates shipping. |
| | Motor No. 1, 50 H.P., drives 8, 10, 12, 13 and 15. | 60 Suction pipe from creek. |
| | Motor No. 2, 50 H.P., drives 6, 19 to 29 and 36 to 38. | |
| | Motor No. 3, 15 H.P., drives 39 to 46 and 48. | |

FIG. 6—VASCO MILL FLOW-SHEET

The whole plant impresses one as being run very carefully and on an efficient basis.

The Mills of the Vasco Mining Company

This company owns two mills. The Boyd Hill mill, situated at Boulder, is a replica of the Wolf Tongue mill, so that no further description is necessary; it may be noted, however, that its full capacity is 30 tons of ore per 24 hours, the mill flow varying between 2 and 45 per cent tungstic acid. The concentrates obtained at this concentrator run between 55 and 60 per cent tungstic acid, and after sacking are shipped to the Vanadium Alloys Co. of Pittsburgh, Pa.

The new mill of the company is situated at Tungsten, Col., not far from the mill of the Boulder Tungsten Products Co. It is known as the Vasco mill. Fig. 5 shows Tungsten, Col., with the Boulder Tungsten Products Co.'s mill in the foreground and the Vasco mill in the center of the picture. The plant was designed to handle 100 tons of ore daily, but at the present time about 30 tons of ore only are treated in 24 hours.

The layout of the mill is illustrated in Fig. 6 and needs no further comment. It may prove interesting to know, however, that the Sampson crusher gives a product of $1\frac{1}{2}$ -in. size. The Universal crusher reduces the over size of the second Grizzly to $\frac{3}{4}$ in. The McFarlane rolls produce a $\frac{3}{8}$ -in. product, which then is elevated to the fine ore bins.

The mill was designed to handle low-grade ores, materials as low as 0.1 per cent tungstic acid having been successfully treated. The general average of the ore probably lies between 0.7 to 2.5 per cent.

The great drawback of this well constructed mill is the scarcity of water for the treatment of the ores. One notes at once upon going through the mill the impure water flowing over the tables and mixing with the concentrates. The result without a doubt is a lower grade of the finished product. However, since the mill sends

its concentrates to the Vanadium Alloys Co., as does the Boyd mill, it is not so vital a question for the company to produce a 60 per cent product. Should the company have to sell the concentrates in the open market it is very doubtful whether the product could compete with that of other mills working under more favorable water conditions.

The method used for obtaining water for concentration is illustrated in Fig. 7. The water is taken from the creek. It filters through a bed of sand and gravel, and then passes through a perforated pipe into a sump from which the clear water overflows into a well 15 ft. deep. It is then pumped into a tank from which point it flows to the mill. The pipe used lies 4 ft. below the bed of the creek and is 12 in. in diameter.

The great difficulty encountered with this system is that the top layer of sand soon becomes covered with a sticky slime, thus preventing efficient filtration. It is necessary to remove this layer from time to time by shoveling, but, at the best, some of this fine material escapes into the water going to the mill. When the creek is low the conditions are even more difficult to handle. Greatest care must then be exercised to prevent any loss of water.

It would seem that from the point of efficiency mechanical thickeners used in the water system would be of great value. The water passing through the mill could be clarified by this means; the results would be a higher grade of concentrates, thus saving the expenditure of shipping so much gangue material East. The concentrates of this mill run between 40 and 50 per cent tungstic acid instead of the general 60 per cent.

The flow-sheet in general is similar in principle to all of the newer mills of the district. A new piece of machinery encountered in this mill is the Flood hydraulic classifier. This classifier takes the undersize of the last trommel screen from which it makes two spigot products and an overflow. The overflow goes to the

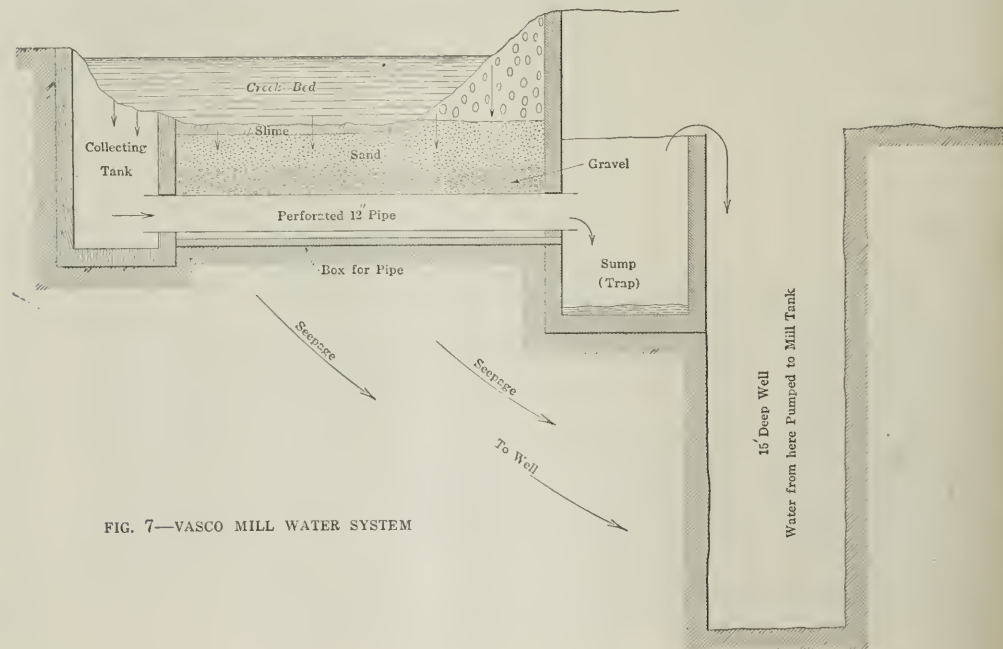


FIG. 7—VASCO MILL WATER SYSTEM

Callow cones. The first spigot product goes to a Wilfley table directly, while the second passes first through a set of Bunker Hill screens and then proceeds to two Card and one slime concentrator.

All the concentrates made in the mill primary to drying are collected in a set of drainage bins. The "rag plant" concentrates are not retreated, but go to the drainage bins as such. In general, it may be said that the mill is capaciously built, allowing room for enlargement and improvement, but as regards water conditions is unfortunately situated. The writer has been informed of contemplated changes, which will result in this mill being of the same types as that of Wolf Tongue mill at Nederland.

Mills of the Primos Chemical Co.

This company owns two plants in the district. The old mill is located at Lakewood, about four miles from Nederland. The new concentrator is located at Copeland on the Moffat Road about six miles from Rollinsville.

Unfortunately the owners exclude visitors from their plant, for which reason it is difficult to make more than general statements concerning these mills. The attitude of the company is due probably to the fact that they do not wish minor details, which aid in the increased extraction of the values from the ore, to become public.

The most guarded secret in every mill of the district is the actual percentage extraction made on the ore milled. Competition between the individual mills is rather sharp and because of the present high cost of tungsten each additional per cent extracted from the ores means a considerable increase in profits for the respective companies.

With a few modifications, it is understood throughout the district, both of the mills are built along the same lines as the mill of the Boulder Tungsten Products Co. at Tungsten. The Lakewood plant was erected to handle 50 tons of ore per day, while that at Copeland has a capacity of 40 tons. The Lakewood mill handles custom ores varying in tungstic acid content from very low to 40 per cent. The Copeland plant, on the other hand, treats ores from the company's own properties which contain from 1 to 6 per cent tungstic acid. The concentrates from both mills are high-grade and are shipped East to the company's own refining plants where they produce tungstic acid of very good quality. The "rag plant" of the Lakewood concentrator has an area of 12,000 ft., which was used to full capacity before rolls and jigs were installed. This latter installation diminished the canvas required for successful treatment from one-half to three-quarters of the initial area and gave a decided increase in the extraction.

It is to be regretted that the members of the Primos Chemical Co. are so reluctant in respect to giving information, for there are undoubtedly few who could give more valuable information on the metallurgy of tungsten than they. As the Lakewood mill is one of the older mills of the district, it has undergone all the changes which has brought it up to the high standard which it now holds. The pros and cons for the changes made could probably fill a book and would be of great value in the metallurgy of tungsten.

The Degge-Clark Mill

This mill is situated in the Boulder Canon and has a daily capacity of 25 tons. The average grade ore treated runs 7 per cent tungstic acid, but ores running as high as 70 per cent in the values are received at the mill from the company's own property at Beaver Creek. The concentrates obtained are high-grade.

The general principles embodied in the construction

of this mill are those of the mills of the Primos Chemical Co. and the Boulder Tungsten Production Co., all of these having been built by the Colorado Iron Works. The ore passes over grizzlies, through Blake crushers, are sampled and passed through rolls. Elevators, a Harz jig, Callow cones, Akins classifier, Wilfley and Card tables are employed similarly as in the mills mentioned, and the slimes are passed over rag tables.

The mill besides handling its own ores also does custom ore work. This mill originally was the old Colum mill before it was remodeled as a tungsten concentrator.

(To be continued)

A Convenient and Inexpensive Electric Furnace for High Temperatures

By A. W. Fahrenwald

An electric furnace in which can be obtained a temperature up to the melting point of platinum is almost an indispensable piece of apparatus in any laboratory. A suitable one is not easily obtained at a price that is not prohibitive. A platinum resistance furnace is suitable for temperatures up to possibly 1600 deg. C., but is better suited for temperatures not exceeding 1300 deg. C., as above this temperature it does not hold up long. Without great care a furnace of this type will be burned out, and owing to the cost of platinum it is practically out of the question, and especially so when the furnace is in the hands of one who does not realize its limit of usefulness.

Resistance furnaces of nickel and some alloys, as nichrome, for example, are suitable for temperatures up to 1000 and 1100 deg. C., and then they do not last for any great length of time.

All furnaces the heat in which is produced by the resistance offered to the passage of an electric current have certain desirable features, such as: 1, rapidity with which they can be heated up; 2, they are under perfect control; and 3, a uniform and constant temperature can be maintained. All these features are combined in the furnace shown in Fig. 1, which is simple in construction, and inexpensive, also comparatively long-lived. The heating unit of this furnace, Fig. 3, is a helix of Acheson graphite made by sawing around the tube, the material sawed out being replaced with alundun cement, which forms then a solid tube which is comparatively strong and can be handled with ease without breaking. The alundun cement also insulates one turn from the other and prevents gases from passing through the helix. This is essentially a springlike structure, and if stretched out would give a film of graphite 20 feet or more in length, and $\frac{3}{8}$ times $\frac{1}{4}$ in. or more in cross-section, depending upon the size of furnace. The one illustrated requires from 25 to 30 amperes at 100 volts for temperatures ranging from 1100 to 1500 deg. C. Temperatures up to 2000 deg. C. are readily obtained.

This furnace, in principle, is essentially the same as that of Arsem,¹ but is not so complicated and is not used in a vacuum, which is inconvenient for most experimental work. Instead of using the graphite resistance coil in a vacuum it is confined in a space between alundun tubes—graphite tubes may be used—to or from which gases cannot readily pass, and in which the gas constitutes an atmosphere in which the resistor element is chemically in equilibrium. The gases present and surrounding the resistor are chiefly carbon monoxide and nitrogen.

¹U. S. Patent No. 785,535, March 21, 1905.

The body of the furnace is inexpensive and simple in construction, and if, when put together, the joints are plastered with alundum cement, it is practically impossible for air to find its way to the graphite resistor, which is readily oxidizable in air above a red heat.

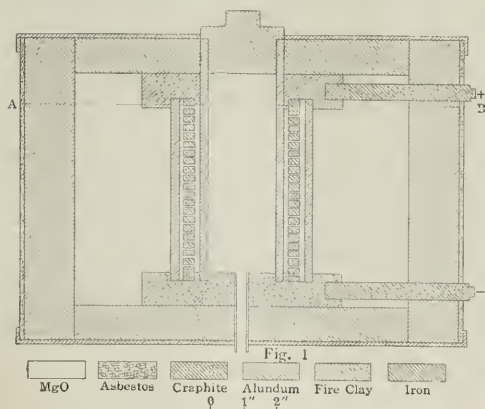
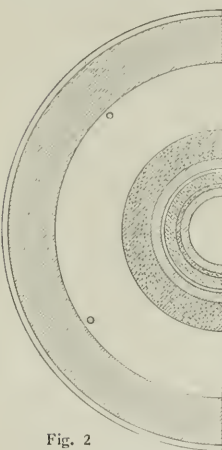
In this furnace, Fig. 1, I have made 36 heats ranging in temperature from 1100 to 1600 deg. C., each for a period of five hours, making 180 hours of service. The furnace is apparently in good shape yet, and I am not prepared to state how long such a heating unit will last. However, when it gives way a new one is readily put in its place by removing the top iron plate, the fire-clay plate, and top electrode immediately below it. Also the inner alundum tube, if necessary. The new unit, which costs from 75c. to \$1.00, is placed in and the furnace assembled, which takes about one hour's time.

Some of the points of advantage of this furnace are:

1. It is inexpensive.
2. Simple in construction.
3. A worn-out heating unit can readily be replaced by a new one.
4. High temperatures can be easily obtained.
5. A uniform and constant temperature can be maintained.
6. The temperature is under absolute control.

A tube furnace can be made exactly similar to Fig. 1.

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Annual Meeting of the Chemists' Club

The annual meeting of the Chemists' Club was held at the clubhouse, 52 East Forty-first Street, New York, on Wednesday evening, May 2. The president, M. C. Whitaker, presided.

The report of the secretary, J. R. M. Klotz, contained some interesting announcements. The membership of the club is now about 1410 as compared with 1291 a year ago. The club has been fortunate in coming into possession during the year of 309 shares of the Chemists' Building Company stock, which company owns the building. This makes a total of 669 shares which the club now owns in its own name. Some additional shares were offered at the meeting which will raise this number somewhat. The announcement was made of the re-establishment of the club paper "The Percolator," due to the generosity of Dr. Edward Weston.

The treasurer, Henry M. Toch reported that the club indebtedness of over \$13,000 had been wiped out and in addition over \$4,000 had been invested by the club.

A proposal to lease the adjoining property to provide additional guest rooms was referred to the Board of Trustees with power to act.

Calls received by the employment bureau in 1915 were 100 per cent greater than in 1914 and in 1916 were 10 per cent greater than in 1915. Forty-four per cent of the calls received in 1916 were filled. So far in 1917 calls are running about 20 per cent over 1916. The number of men registered in 1916 was 978.

The announcement was made of the awarding during the year of the Victor Bloede and William Hoffmann scholarships which had been founded last year.

The president, M. C. Whitaker, resident vice-president G. W. Thompson, secretary, J. R. M. Klotz, and treasurer, Henry M. Toch, were re-elected for the coming year. W. D. Bancroft was elected non-resident vice-president and David W. Jayne and John H. Teeple were elected to the Board of Trustees.

Following the regular meeting a special meeting of the trustees was held and food and entertainment was provided to enliven the occasion following the meetings.

The announcements made showing the club's progress were very gratifying and the meeting was thoroughly enjoyed by all those who attended.

Tin Smelter for Chile.—Compania Chilena de Fundicion de Estano (Chilean Tin Smelting Company) has been organized with capital of £50,000 (243,000) to establish a smelter in the port of Africa, Chile. It will smelt tin concentrates from Bolivia. The committee of engineers having charge of the installation of this smelter is composed of Guillermo Yunge, Durward Copeland and Richard Gabler. Tin ingots 99.75 per cent fine will be made.

Resolutions on the Use of Platinum.—In addition to the resolutions passed at the recent meeting of the American Chemical Society at its Kansas City meeting, urging women not to wear platinum, the Platinum Committee of the Jewelers' Vigilance Committee has passed resolutions recommending to all manufacturing and retail jewelers that they discourage the manufacture, sale and use of platinum. The National Academy of Science has passed resolutions similar to those of the American Chemical Society. The needs of the government itself for platinum will undoubtedly be met during the present war with great sacrifice. While the government itself uses comparatively little platinum, our sulphuric-acid industry, especially for the strong acid used in the production of high explosives, is dependent upon it, while its high price makes it almost prohibitive for scientific research.

Spring Meeting of American Electrochemical Society at Detroit, Mich.

The thirty-first general meeting of the American Electrochemical Society, held in Detroit, Mich., from Wednesday, May 2, to Saturday, May 5, will always be remembered as one of the most profitable and most enjoyable held by the Society. With the country at war, there was a natural serious background to all the proceedings, even to the jolly merriment of the incomparable smoker of Section Q. There were excellent papers, with some good and animated discussion, though almost too many papers had been crowded into the four technical sessions. From the very beginning to the end there was manifest a get-together spirit that reminded one of the far-away days of fifteen years ago when this society was founded. The Detroit meeting more than any other was characterized by a getting together of electrochemists and electrical engineers in an enlightened spirit of mutual helpfulness.

Mr. Edwin L. Crosby of the Detroit Edison Company, as chairman of the local committee, was untiring in making everybody feel at home. Not a word too much was said when the official vote of thanks at the end of the meeting spoke of him as the "efficient and genial" chairman; and all committees worked with such smoothness and efficiency that it was hard to say whether the carefulness of making the arrangements or the accuracy of execution were more to be admired. The executive committee consisted of Messrs. S. L. Bigelow, E. C. Burdick, A. D. Cowperthwait, John Cranston, J. L. Dixon, Y. F. Hardcastle, E. G. Henderson, B. K. Koering, A. L. Marsh, E. M. Schmelz, R. S. Stewart and F. T. F. Stephenson. The reception committee consisted of Messrs. J. D. Noyes, E. J. Posselius, R. S. Stewart and P. J. Savage. The transportation committee consisted of Messrs. J. M. O'Dea, A. D. McLay, John Kruesi, H. M. Lane, H. E. Lowe and A. J. Duke. The ladies' committee, which had arranged a most enjoyable program for the entertainment of visiting ladies, consisted of Mrs. Edwin L. Crosby, Mrs. Ward D. Dygert and Mrs. John D. Noyes. Special credit is due to Miss Edna J. Raybould, who, as secretary to the committee on arrangements, answered endless questions with indefatigable good nature.

On Wednesday evening there was an enjoyable "get-together" subscription white-fish dinner at the roadhouse "West Wood." On Friday evening an address was to have been delivered by the distinguished president of the Detroit Edison Company, Mr. Alex Dow, on "Electrical Power from Coal." Unfortunately, Mr. Dow was detained East, and the lecture had to be called off. A theater party (Treasure Island) was substituted. Thursday evening was the night of the smoker.

The Smoker

The smoker held on the roof garden of the Hotel Tuller, on Thursday night, was the most elaborate and

unique smoker ever held anywhere. That much must be acknowledged, and was officially acknowledged at the end of the whole meeting in the vote of thanks, in which for the first time the existence of the unofficial Section Q was officially recognized. The smoker committee consisted of Messrs. W. D. Dygert, W. J. Fitzgerald, W. L. Granger, C. F. Hirshfeld, L. H. Gumm and W. F. Bartels, but Mr. Edwin L. Crosby and Mr. F. A. Lidbury also had a great deal to do with it; and as to the performance, there is not a man in the United States that could have equalled Mr. David Sowers of Buffalo in the special part he took. It's a pity that it cannot all be told here.

For the entire evening "all discussion regarding depressing subjects such as war, delivery on electrical apparatus, price of electrodes, etc.," was officially forbidden. But there was a wireless station working in the room, and war bulletins and other bulletins were put on the screen.

There were refreshments and songs and poetry, real Section Q poetry. In a songbook most of the Section Q productions had been collected since 1908 (but any collection without Sue is incomplete), and a great deal of new poetry for the Detroit meeting had been added. There were many personal hits, but nobody cared, and our New York friends who were responsible for the unfortunate ballroom smoker at the last New York meeting have asked us to quote the last two lines of the song "to make the punishment fit the crime": "And our New York collection of plutocrat dubs is sentenced to sit through a smoker. When there's nothing to do, and no one knows Sue, and Coho's the principal joker."

And there was a brand-new ballad of the Q 23 as to how the Eastern members traveled by submarine to Detroit. ("We stopped for ballast at Syracuse, And loaded her down with Doc Mathews; But when we started we found his weight Somewhat exceeded our estimate. Way down, totally submerged, Way down, with just our periscope emerged—So we steered her south to Ithaca and picked up Wilder D. As expert on flotation to the Q 23.") Bulletins on the screen announced the stops of the trip and the safe arrival.

More refreshments and songs and bulletins came, and more songs and more bulletins, and then came the crowning success of the evening, a play entitled "Research in Hell," a flight in two tail slides and one spiral drive, a futurist impression of Mephistopheles' Research Laboratory (electric furnace used by consent of all applicants for patents at U. S. Patent Office). It was wonderful. We are not sure which was greater, whether the united Detroit & Niagara imagination that invented plot and poetry, or the execution of the performers, from Hinkley's Mephistopheles down to the ammeters and voltmeters actuated by Seede's and Turnbull's electrode



COLIN G. FINK
President American Electrochemical Society



GROENWALL-DIXON FURNACE

regulators. It ended with the coronation of Sir Joseph, N.C.B., and there we leave it.

Visits to Industrial Plants

On the afternoon of Wednesday a very enjoyable visit was paid to the automobile factory of Dodge Brothers, where the whole evolution of the Dodge car was seen at a glance. Of particular interest was the electric japanning oven employed there (to which the paper by Professor Hirshfeld, presented in the Friday session, and printed later in this report, referred). At the end of the visit there were two moving-picture shows, one relating to a Pacific Coast trip of a Dodge car under very trying and difficult circumstances, the other to the use of automobiles for military service.

Smaller parties to the Ford plant and the Packard plant had been arranged for Friday.

The afternoon of Friday was entirely devoted to

a visit to the two electric steel plants of Detroit, that of the Michigan Steel Castings Co. and that of John A. Crowley Co.

At the Michigan Steel Castings Co. two Heroult furnaces are in operation, one of 6 tons and the other of 3 tons capacity. As to the method of operation and the results obtained, the reader may be referred to the paper by Mr. R. F. Flinterman on a following page. To Mr. Flinterman, president of the Michigan Steel Castings Co., our thanks are due for courtesies received during the visit.

At the John A. Crowley Co.'s plant a Groenwall-Dixon furnace of 5-ton capacity is in operation, while a larger furnace of 10 tons is in course of construction. This is the well-known Groenwall furnace as improved by Mr. J. L. Dixon, and it was our particular pleasure to have Mr. Dixon as guide through the plant. The John A. Crowley Co. controls the U. S. and Canadian patents of the Groenwall-Dixon furnace.

A photograph and drawings of this furnace are herewith reproduced. It was started in operation in July, 1915, and on July 22, 1916, the anniversary of the initial heat was duly celebrated. During the first year 5000 tons of chrome-vanadium steel, nickel-chrome steel, nickel steel, and other steels had been made in the furnace, and the design had come up fully to expectations in every respect.

The furnace is operated by two-phase currents, and has four top electrodes, two of them being connected to one phase, the other two to the other phase, while the neutral point of the two-phase system is connected to the bottom. The bottom electrode is of carbon, and is protected from the metal by being embedded under the lining.

While the furnace is operated on a two-phase system, a three-phase supply is taken through two banks of transformers and changed to two-phase by a modified Scott connection. The heats average four to five hours, with a specific consumption of 460 to 600 kw.-hours per ton, depending on the kind of scrap used, the degree

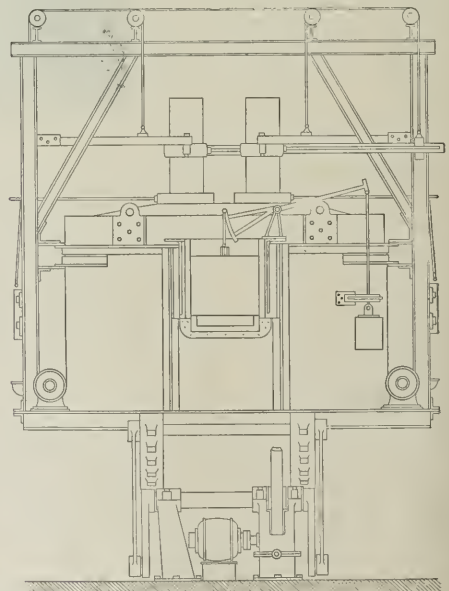
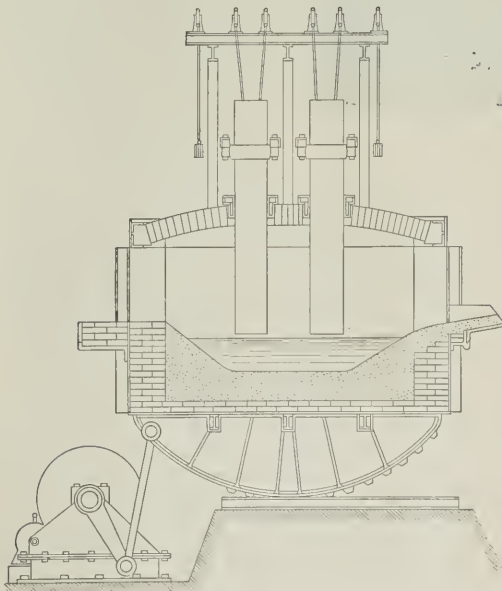


DIAGRAM OF GROENWALL-DIXON ELECTRIC STEEL FURNACE

of refining desired, etc. Our sincere thanks for courtesies received are due to Mr. Dixon.

Mr. Marcy extended an invitation to visit the Air Reduction Company's plant (oxygen from liquid air) and Mr. Quaintance had at the Hotel Statler a fine exhibit of Herold chemical porcelain.

Annual Business Meeting

The annual business meeting was called to order on Thursday morning by President F. A. J. FITZGERALD in the ballroom of the Hotel Statler.

The secretary, Dr. Joseph W. Richards, read the reports of the Board of Directors and of the Membership Committee. On motion of Mr. Lidbury, seconded by Dr. Fink, the thanks of the society were extended to the chairman of the Membership Committee, Dr. Schluederberg, for his most efficient work during the past year.

Election of Officers

The result of the election of officers for the coming year was then announced as follows:

Dr. Colin G. Fink, head of the Research Laboratory of the Edison Lamp Works, General Electric Co., Harrison, N. J., is the new president.

Mr. H. C. Parmelee, president of the Colorado School of Mines, Golden, Col.; Dr. F. C. Frary, Oldbury Electrochemical Co., Niagara Falls, N. Y., and John Wood Beckman, Great Western Electrochemical Co., San Francisco, Cal., were elected vice-presidents.

Mr. L. E. Saunders, general manager Norton Co., Niagara Falls, N. Y.; Dr. John A. Mathews, president Halcomb Steel Co., Syracuse, N. Y., and Mr. A. T. Hinkley, National Carbon Co., Niagara Falls, N. Y., were elected managers.

Mr. Pedro G. Salom of Philadelphia, Pa., was re-elected treasurer, and Dr. Joseph W. Richards of Lehigh University, Bethlehem, Pa., was re-elected secretary.

Dr. Colin G. Fink, the new president, was born in New Jersey on December 31, 1881. He graduated at Columbia in 1903, and then spent four years in the Ostwald laboratory at Leipzig. Here he obtained his doctor's degree in February, 1907, "summa cum laude." During his last year at Leipzig he was assistant in electrochemistry. Upon his return to America he entered the General Electric Research Laboratory of Dr. Whitney at Schenectady, and there devoted himself in particular to the metallurgy of tungsten. His discovery of "ductile" tungsten was announced for the first time at the American Electrochemical Society, meeting at Pittsburgh in May, 1910. He introduced the tungsten wire process at the Edison Lamp Works of the General Electric Co. at Harrison in 1910, and has been connected with these works ever since. He is in charge of the research laboratory there. One of the important products of his laboratory is the platinum substitute leading-in wire, a compound copper or cobalt wire with a corrected expansion coefficient (Engl. pat. No. 23,775). This wire has been in universal use for a number of years, and the conservation of platinum amounts to millions of dollars per year.

Resolutions on Water Power and Niagara Power Legislation

The chief business transacted during the business session was the unanimous adoption of a resolution on water power legislation and of a resolution on Niagara power legislation. These two resolutions had been originally prepared by the Committee on Public Relations, had been adopted after thorough discussion with some modifications by the Board of Directors, and were

now finally adopted by the society as a whole. The two resolutions read as follows:

WATER POWER LEGISLATION

"In legislation affecting water power the American Electrochemical Society wishes to point out why primary consideration should be given to the needs of electrochemical industries.

"(1) The electrochemical industries, upon whose products many of the principal industries of the country entirely rely, depend in their turn (with the exception of certain branches, such as steel melting, some metal refining, etc.) upon an ample supply of power at prices such as are made possible by hydro-electric generation.

"(2) The dependence of general industries on electrochemical products is so great, and the industrial improvement made possible by these products is so far reaching, that the use of water power for electrochemical purposes benefits the people as a whole.

"(3) Recent advances in steam engineering have brought about a condition in which it is, in most cases, no longer economical to employ water power for purposes which do not utilize the power to its full extent all the time; and considerations of conservation also demand that power generated from waterfalls be utilized completely all the time, and not be used intermittently.

"(4) Electrochemical industries are able to absorb such power fully and continuously, and only for this class of load, as a rule, is the utilization of water power now economical. Therefore its use in this way benefits the people as a whole far more than does its local use for domestic purposes, street railways and lighting, and other ordinary power purposes.

"Most of these electrochemical industries are at present suffering from an extreme shortage of developed water power, and as a consequence they are now unable to supply the urgent demands upon them, a condition which will result in giving to other countries an advantage over the United States in the manufacture of products of vital necessity, in times both of peace and war.

"(5) It also appears probable that the time is not far distant when this country must rely on the fixation of atmospheric nitrogen to render it independent of external sources of nitric acid for the manufacture of military explosives, and possibly for the production of fertilizers needed to maintain its food supply. The immediate impediment to the development in the United States of processes already working commercially abroad has been the scarcity of cheap power.

"In view of the mutual dependence of the futures, respectively, of these electrochemical industries and the development of water power in this country, and the great importance of the matter to the nation as a whole, the American Electrochemical Society believes that no legislation affecting water power should be enacted without giving a careful hearing to the electrochemists of the country."

NIAGARA POWER LEGISLATION

"The immediate future of a major portion of our electrochemical industries depends on a considerable extension of power generated at Niagara Falls more than upon any other factor. The interests of all—scenic beauty, navigation, and industry—are suffering from the absence of positive action based upon the co-operation of all concerned, both in the United States and Canada. The American Electrochemical Society believes that it has been sufficiently demonstrated that means can be devised for the utilization of far larger

quantities of water for power at Niagara Falls than are at present allowed by the treaty, under conditions which will not only maintain the scenic beauty of the Falls, but will at the same time prevent the steady deterioration of the spectacle due to the uncontrolled natural erosion of the Horseshoe Falls, and will assist in the improvement of navigation in the upper Niagara and Lake Erie. (See Appendix by J. L. Harper.)

"The American Electrochemical Society therefore suggests the formation of a joint commission containing representatives, from both the United States and Canada, of the government engineers and of organizations interested respectively in the preservation of scenic beauty, in navigation, in electrochemistry, in power development, and so forth, and respectfully requests the administration of the United States Government to take the initial steps toward the organization of such a commission, or to take such other action as may best forward the investigation urged by General Black and indorsed by the Secretary of War."

Both reports were unanimously adopted as reports of the society as a whole.

Of the numerous appendices of the two reports adopted, the appendix on the Suicide of the Niagara Horseshoe Falls, by John Lyell Harper, deserves particularly general attention and is herewith reproduced in full.

The Suicide of the Niagara Horseshoe Falls

By John Lyell Harper

A map of Niagara Falls and the Niagara River has recently been brought to the writer's attention as giving the best illustration possible of the extent and character of the recession of the Horseshoe Falls. This old map was made under the direction of Colonel Bradstreet of the British Army in the year 1764, and is in a fine state of preservation.

The map accompanying this article gives the location of the crest of the Falls in 1764, together with the loca-

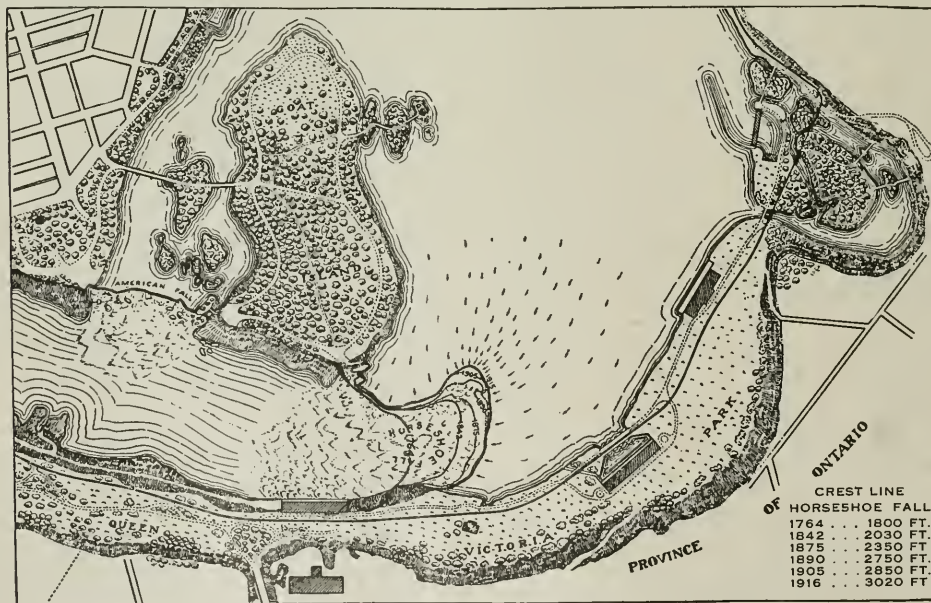
tions of the crest at later dates, and shows at a glance the conditions obtaining.

The change in appearance of the Horseshoe Fall has always been noticeable within the span of an ordinary lifetime, but passed without serious concern until the subject was taken up by those who imputed this change to the diversion of water for power purposes, though it would seem obvious that, with the lengthening of the crest of the cataract, even an undiminished volume of water would not cover it as deeply as when it was shorter.

Noting the location and character of the recessions shown on the accompanying map, which have been at the average rate of 6 ft. per year for 150 years, it may be easily determined that the depletion of the cataract on the sides of the Horseshoe is due almost entirely to the cumulative effect of a constantly increasing volume of water in the center of the river, causing a constantly increasing recession at that point and a more rapid deepening of the river there.

As early as 1908, when government engineers were making an investigation to determine the effect upon scenic grandeur of a diversion of water from the river, a report was made by Major Charles Keller to the Chief of Engineers of the United States Army, and incorporated in Senate Document No. 105, Sixty-second Congress, which states as follows:

"While the preceding conclusion as to the effect produced upon the Falls by existing diversion is a statement of opinion based upon ascertained facts, the interests of justice seem to demand the further statement that, in my opinion, the damage already done, and that which may be anticipated from further diversions and from the impending fall in the level of Lake Erie, may be largely, if not entirely, remedied by a submerged dam placed in the bed of the river immediately above the Horseshoe Fall. The dam, if properly planned, would serve to change the direction of the flow so as to increase the streams that feed the Falls at Terrapin



MAP OF NIAGARA FALLS, SHOWING SUICIDE OF HORSESHOE FALLS

Point and at the Canadian shore. The decrease in the mighty volume that overflows the center of the apex of the Horseshoe would not be noticeable. . . . A very direct result of the construction of this submerged dam would be a diminution in the rate of recession of the apex of the Horseshoe. This in itself is extremely desirable."

It is not probable that Major Keller at that time assumed to determine the only way of accomplishing the result, but it is apparent from his report that the fact could have been placed then fully before Congress if a complete report had been required of him.

Another report made in September, 1911, by Lieutenant Colonel C. S. Riche of the United States Lake Survey Office states as follows:

"A large part of the water descending the Horseshoe Fall passes over the center or apex. The recession of this portion of the crest line, due to the enormous flow, is progressing at a rate of about 5 ft. per year. In turn, the overflow is becoming more concentrated, and the depths on other portions of the crest are necessarily being decreased. Gage relations indicate that the surplus over the apex is drawn principally from the Canadian shore. Since 1906 the effect has been a lowering, at mean stages, of $\frac{1}{2}$ ft. over the west end of the Fall."

An entire cessation of diversions from the river would not retard the recession of the Horseshoe, but would rather accelerate it. In fact, no negative action by the government will accomplish a remedy, but a positive action must be taken.

Niagara Falls, "bone-dry," and with a total water diversion for power purposes is, of course, an interesting picture drawn as a reason for opposing any commercial development, but to those whose lives and energies are daily in contact with the mighty cataract it represents as unattainable a limit in one direction as does the entire absence of development a wasteful limit in the other direction.

Any observer of the Niagara River during the winter season, when almost its entire surface is covered with masses of floating ice, will appreciate that a large percentage of the outflow of the river must be reserved, either joyfully or grudgingly as the case may be, for the disposal of this ice. Otherwise, if allowed to stop it would gorge the river all the way to Lake Erie, shutting off the water until it was melted by the heat of the sun in the spring. An estimate of 40 per cent of the volume of the river for ice transportation seems to be reasonable; therefore, under the maximum proper development, this 40 per cent of the total amount of water would be continuously available for the production of scenic effects. It may be interesting to consider what can be done with it.

The American Fall, with its 1000 ft. of crest, now discharges about 5 per cent of the volume of the river and, in the opinion of many, produces at least 25 per cent of the spectacle. This Fall would be maintained in the same condition as it is at present. Then 35 per cent of the river could be discharged over the 3000 ft. of crest of the Horseshoe Fall, and would make a cataract three times as long and twice as deep as the present American Fall.

The scenic effect of this permanent re-establishment would, undoubtedly, be more pleasing than the present one, where at least 75 per cent of the water passes over a part of the crest barely visible to the observer and is useless for any purpose, scenic or otherwise.

The particular method of distributing the water evenly over the crest of the Horseshoe Fall cannot be determined with exactitude without full and competent study, but it should be accomplished by means of in-

visible deflectors of such form that there would be no artificial structure visible to the eye. In other words, a perfect distribution should be the only requirement, the means and methods being left to the engineering representatives of the governments of the United States and Canada, under the supervision of future and present commissions having jurisdiction in these matters.

General Black, in his report to a congressional committee under date of Jan. 30, 1917, has amplified the previous statements of Major Keller, and the following paragraph is taken from his report:—

"In the Falls of Niagara the world has one of its grandest and most majestic national wonders. Also it has there a source of power practically unexcelled in amount and convenience of location. There is no question but that, while the beauty and grandeur should be preserved, the source of power should be utilized to the maximum extent possible. There is thus presented a problem of magnitude, but not one which is insoluble. Study and care are essential if the best results are to be obtained. In my judgment, piecemeal legislation authorizing piecemeal development is inadvisable. Congress should have before it full information as to what can be done in the way of protecting and compensating construction which will permit the maximum diversion of water from the higher level or levels, and as to how water, thus diverted, can be most fully utilized in the production of water. Though the views of this department have been requested repeatedly as to partial aspects of this question, it has never been authorized to make a full investigation."

The above paragraph shows that Congress has before it very clear and concise statements of fact and it is to be hoped that, from the standpoint of electrochemists, early action may be taken which will allow a continuation of the splendid progress made by our scientists, which has not only filled us with pride but is an absolute necessity to our industrial life.

* * *

The business session being at an end, President Fitzgerald presented his scholarly presidential address, which is herewith reproduced in full. It was listened to with intense interest, and deserved the prolonged applause which it received.

The Committee on Public Relations

Presidential Address Delivered at the Detroit Meeting of the American Electrochemical Society on May 3, 1917

By Francis A. J. Fitzgerald

The last three presidential addresses seem to have established a precedent as to the nature of that discourse which I propose to follow because the precedent is probably a good one, and also because the subject happens to be the one to which I have had to give more time than to any other during the past year.

Until Roeber in 1914 discussed "some Economic and Aesthetic Aspects of Electrochemistry," presidential addresses were usually devoted to more or less technical subjects. In 1915, however, Lidbury¹ chose as his subject "The American Electrochemical Society and Its External Relations," and when Addicks' last year spoke on the "Modern Engineer," he undoubtedly had in mind his idea of the Committee on Public Relations which he had asked the Board to create. Thus, the more recent presidential addresses have been devoted to the relations of the Society to matters of public interest rather than to strictly technical subjects.

This is certainly a symptom of the growing consciousness of the duty of individuals and their numer-

¹This journal, vol. XII, p. 344.

²This journal, vol. XIII, p. 277.

³This journal, vol. XIV, p. 475.

ous groupings to the democracy to which they belong. This growth has been noticeable for several years, and has been enormously stimulated by the Great War which is trying out democracy as it has never been tried before. Will it prove in this great trial that a government by the people can be carried on successfully with the maintenance of the principle that the State is made for man and not man for the State? Democracy demands something more than a government to which the governed consent. It should be controlled by the individuals and social groups of which it is composed, and should be for what these consider conduces best to their happiness. In order, then, that a democracy shall be successful, the individuals and social groups must take a paramount interest in governmental problems. We are learning that this is necessary, and that its lack is one of democracy's most serious weaknesses. The lesson is being driven home all the more rapidly by the great struggle between democracy and another system of government characterized by a far higher efficiency according to its exponents.

How, then, can a social group like our Society serve in strengthening that form of government which we consider necessary to preserve the rights of Life, Liberty and the pursuit of Happiness?

The creation of the Committee on Public Relations is an attempt to answer this question and the proposed activities of the committee are indicated in the resolution presented by A. H. Hooker as follows:

"Resolved, That this society endorses the action of its Board of Directors in appointing the Past-Presidents of the Society under the chairmanship of the President, as a Committee on Public Relations, and expresses its confidence in that committee and its ability to represent the society in giving advice to legislative committees and other bodies."

In seconding the resolution, F. J. Tone said:

"I desire to second this resolution and in doing so I desire to take the opportunity of saying that technical societies have a great opportunity to-day to make their opinions and their influence felt on public questions. I hope that this society will avail itself of this opportunity to the fullest extent."

There appear to be three main classes of subjects in which the Committee on Public Relations should act:

1. Subjects dealing with public questions which are referred to the society for action either by members or outsiders.

2. Subjects on which advice is asked for by the Government.

3. Subjects of public interest and relating to electrochemistry should be studied by the committee, and steps taken to initiate action on these by the Society or its members.

In the past year subjects in each of these classes have been dealt with by the committee.

As regards certain questions in the first class which have been submitted to the society, the committee has advised that no action should be taken, on the ground that these are not related directly to the society's activities, or are not subjects on which the society's opinion is of exceptional value. A good example of this kind of question was a resolution on the subject of "Preparedness," which was sent to the society with a request that it should be submitted to the members for action. The committee decided against taking any action, not because it was opposed in any way to the sentiments expressed; but because this particular resolution covered a question that obviously was one

for the public in general to pass on, and not for a particular technical society.

It was felt that if the society passed resolutions on all kinds of public questions that were not particularly related to its activities, this would weaken the effect of any resolutions it passed on subjects about which it could offer a really expert opinion.

Incidentally this resolution called attention to the question of expert advice, for in one clause it offered an opinion as to the size of navy which the United States ought to have. Possibly a heterogeneous mass of citizens might find an excuse for offering an opinion as to how big our navy should be, on the ground that this expression was based on the expert advice of those competent to give it; but a society composed of individuals presumably more or less expert in their particular branch of technical work should understand the value of expert opinion, and therefore recognize its own limitations.

One of the special weaknesses of democracies is found in their appreciation of expert advice. The expert is not ignored, but he is not appreciated correctly. On the one hand we find frequent examples of the hired expert whose advice is ignored by his employers probably because of a perverted democratic instinct which dislikes all submission to authority. In private affairs those who are called on to act as experts could give numerous examples, and in public matters do we not continually see the impudent ignoring of expert advice in highly technical matters by Congress? On the other hand, we must admit that your expert is too apt to think that special knowledge in work of one kind entitles him to promulgate *ex cathedra* opinions on subjects about which his utterances are far from authoritative—and he is taken seriously. Thus while tacitly agreeing with the flippant treatment of expert opinion by our political representatives our democracy is apt to swallow respectfully the opinions of a great mechanical and electrical inventor on the physiological effects of cigarette smoking or the historical and ethical considerations of war by a distinguished ichthyologist.

Under an autocracy there is a truer appreciation of the expert, and consequently a much more efficient use of his abilities. His patrons are members of the governing class, and hence it is merely necessary to satisfy them in regard to his expert knowledge, a far easier task than that of exciting the attention and winning the confidence of a democracy. True, the democracy has its representatives who attend to matters of government, but the scientific or technical man cannot depend upon these alone for recognition. These representatives are chosen by the people, and before being chosen they must convince their constituents that they are more or less experts in their own line. To expect these representatives to convince their constituents that the scientific or technical men are worthy experts is expecting too much. That is obviously a task which must be undertaken by the scientific and technical men themselves.

There is no matter requiring more careful consideration by the Committee on Public Relations than that of cultivating in a democracy a true appreciation of expert opinion. The difficulty of this task is great, as is shown by the experience of army and naval experts, and indeed all technical men employed by the government. In their case, however, the difficulties are exaggerated on account of their relation to the government, which must inevitably curb their freedom to a certain extent. The learned and technical societies, however, are not handicapped in this manner, and therefore are perfectly free to exert every effort to win the interest and confidence of their fellow citizens.

Besides distinctly constructive activity of this kind, the committee should remember the necessity of guarding against certain dangers which are likely to be present in democracies. One of these is the development of what might be described as political experts as distinct from expert politicians. The latter is a necessity, the former an injurious nuisance.

We often have occasion to complain of the blunders of our expert politicians, particularly in their treatment of technical matters, and are apt to imagine that could we take their places, things would be much better. They would, in fact, be far worse giving results such as might be expected if a politician were to take charge of the running of an electrochemical plant. The electrochemist who tries to undertake political work in relation to electrochemistry will end by being neither a good electrochemist nor a good politician. In politico-electrochemical matters we must remember that we can only play a complementary part to the politicians. The politician is as useful a member of society as the electrochemist, and the whole profession need not be condemned because of those who are incompetent. An incompetent electrochemist is not an impossibility.

Finally let us remember that our special activities contribute no mean part to the great mass of scientific and technical work which has done so much for the welfare of humanity, and in so far as this is true we may fairly ask for the admiration of those who, with the virtuous king of Brobdingnag, hold the opinion that "whoever could make two ears of corn, or two blades of grass, to grow upon a spot of ground where only one grew before, would deserve better of mankind, and do more essential service to his country than the whole race of politicians put together." But let us not forget that this wise king, when Gulliver told him of certain wonderful machines developed by his race, was "struck with horror at the description I had given of those terrible engines and the proposal I had made. He was amazed how so impotent and groveling an insect as I (these were his expressions) could entertain such inhuman ideas, and in so familiar a manner, as to appear wholly unmoved at all the scenes of blood and desolation which I had painted as the common effects of these destructive machines, whereof, he said, some evil genius, enemy to mankind, must have been the first contriver."

Let us then remember that no matter what advances we make toward the development of new processes and inventions, we are only doing half of our duty, and cannot in justice pose as benefactors of humanity unless we also do our part in seeing to it that the results of our labors are so wisely employed that they will prove to be blessings rather than a curse.

Electric Steel

The first six papers presented during the technical sessions related to electric steel. Three were read in the Thursday morning session, the other three in the Thursday afternoon session.

History and Present Status of Electric Steel

A paper by Dr. John A. Mathews, president of the Halcob Steel Co. of Syracuse, N. Y., entitled "Comments on the Electric Steel Industry," was the first to be presented. In the absence of the author it was read by Dr. Richards.

Dr. Mathews referred to the prophecies of Sir William Siemens on electric steel melting forty years ago and to the first Canadian Commission Report in 1903, and to the use, by Dr. Heroult and others ten or more

years ago, of a duplex process, using an open-hearth furnace for preliminary melting and refining, the liquid steel being transferred to the electric furnace for de-oxidation, desulphurizing and for making of additions or adjustment of the desired analysis. The first American installation of this kind was made at the Halcob Steel Company under the author's direction and is now in its twelfth year of operation.

Other plants soon appeared here and abroad, nearly all using the duplex process. In addition to the belief in the metallurgical soundness of the process, there was the further belief that electricity could not be successfully and commercially used to do the first melting, and this was true at the time, but now the lower cost of wholesale power and increased electrical efficiency make cold melting feasible in many localities.

At the May meeting of this society in 1909, Mr. Paul Girod, the well-known inventor of the Girod furnaces and a successful manufacturer of steel and ferro alloys in France, challenged the electric refining idea, and stated that one cannot make steel of crucible quality in the electric furnace starting with a molten charge of open-hearth or Bessemer metal.

"After twelve years as pioneers in operating this process in America, we can truthfully say we have suffered no disappointment. Just recently has come to my attention the case of a very difficult government specification, which has never been successfully met by any other material, and I know that at least two or three firms furnishing material melted in the electric furnace from cold scrap have failed to meet it. It must be admitted, however, that most of the recent electric-furnace installations are intended for cold melting. We have two such installations in operation and two under erection, but this is not because of any difficulties with the duplex method, which will certainly be continued. Having tried the two methods of melting, side by side, for a considerable period we see no reason for accepting Mr. Girod's conclusions. In fact, if electric furnaces of large size, say, from ten tons and upward, are to be a success, we believe it will only be upon the basis of using molten charges. They are not altogether successful as cold melters.

"The choice of processes seems to be an economic rather than a metallurgical consideration, and local conditions for each installation must govern the choice, while the final success by either process is a matter of individual skill of operation.

"The electric furnace has not replaced the crucible furnace or crucible steel; its field has been the 'production of very high-class steel for special purposes,' as stated in Harbord's second conclusion. In this capacity the electric furnace was most timely to meet the demands for just this class of material, which arose simultaneously with the birth of the automobile and aeroplane industries. New requirements for materials of construction came into being along with them, and it is in meeting these requirements that the electric furnace finds its best and greatest application. To these, of late, have been added the requirements for munitions of war. Our own furnaces, so far, have not been used for this class of material."

Why, then, does the electric furnace with proper handling produce a superior product for the most severe requirements of automobile, aeroplane and munition manufacture?

"First: Experience shows that chemical composition of consecutive heats can be held more closely to a standard than with any other process. This is most noticeable when handling easily oxidizable metals like vanadium, chromium, silicon and manganese.

"Second: From the above it is apparent less of these

⁶⁶"Gulliver's Travels," Jonathan Swift.

¹*Ibid.*

metals will have to be added to ensure a given final minimum, hence there will be less of the oxides of these metals produced in the steel and to be removed from the steel.

"Third: The more nearly composition can be controlled, the more certain are likely to be the results of subsequent heat treatments.

"Fourth: Electric steel is usually chemically purer than any other steel. Sulphur, especially, is readily removed. There has been considerable written of late to show that the effects of sulphur are not as harmful as generally believed. Be that as it may, when the sulphur is uniformly distributed, yet it is obvious that segregation of elements is impossible if they are absent. It also follows, if segregation of sulphur and phosphorus are not to be feared, the percentage of cropping may be reduced and the yield of sound metal increased—a step in the direction of economy and conservation.

"Fifth: Low sulphur in electric steel usually means a prior reducing condition favorable to complete deoxidation. This condition is favorable to sound ingots, freedom from blow-holes and seams produced from them. Quiet metal has less tendency to segregate in the mold, as to either metallic or non-metallic elements, and produces steel free from 'ghost' lines or laminations.

"Sixth: Alloy additions may be made in the furnace itself rather than in the ladle, which increases the chance of thorough assimilation, diffusion and homogeneity.

"Seventh: From a combination of the above reasons, it unquestionably results that electric steel is less easily injured by overheating than is the case with other steel. It will stand more heat in the forging or heat treatment without injury; that is, it has a wider safe heat range. This opinion has the weight of both experimental evidence and practical experience in the hands of competent observers among users.

"Eighth: Electric steels are usually freer from slag and non-metallic inclusions than are Bessemer and open-hearth steels.

"Ninth: All of the above characteristics make for quality, when quality is the first consideration. The electric furnace possesses an economic value in its adaptability for handling and recovering alloy scrap values. Some alloy scraps do not make desirable additions to open-hearth furnaces or, if made, a large share of the alloy metal is lost in the slag. With the widespread and increasing use of alloy steels it is highly desirable that alloying elements be not lost when contained in the scrap.

"These advantages and others follow because, as Siemens observed, 'the fusion is effected in a perfectly neutral atmosphere,' and because a number of distinguished engineers and inventors produced commercial, workable furnaces in which these results could be attained on a large scale.

"Electric furnaces, like automobiles and aeroplanes, are of little use without skilled operators. They are not automatic devices which run themselves. Carelessness in their operation will lead to disastrous results. They are not nearly as foolproof as crucible furnaces, which require considerable skill but of a different order from that required for electric melting, assuming that steel of equal quality is to be produced by either process. . . ."

"The United States has taken the lead in electric-furnace development, after a very slow start in which we seemed to be lagging behind some of the European countries. In our own plant we have grown from 500 k.v.a. to 5500 k.v.a. of installed capacity for electric melting, while in the U. S. A. there is no less than 150,000 k.v.a. in operation or just being installed. The annual tonnage capacity of the furnaces using this current I estimate to be about 1,250,000 gross tons of

ingots and castings. It is impossible to figure this exactly, because some furnaces may operate on either refining or cold melting charges, and, of course, the output is much greater when the former method is used. This infant industry already represents an output about eight times as great as the crucible-steel production and one-eighth that of Bessemer production. These two processes are not declining but are more or less stationary, with wide annual fluctuations."

The author closed with emphasizing the necessity of wise state and national policies affecting hydroelectric developments.

Dr. Mathews' paper was discussed at some length by Mr. Dixon, Dr. Lindsay, Dr. Richards and Mr. Turnbull. Mr. Turnbull said that in Canada the electric furnace can operate 15 or 18 dollars more cheaply than the acid open-hearth under present conditions and for some years to come. The first electric steel furnaces in the United States were for duplex operation, but the really first ones in Europe were for cold melting. Mr. Dixon and Mr. Turnbull referred to the difficulty, objected to by older steel makers, in removing the oxygen from steel overoxidized in the open hearth; but much has been done in recent years in this connection. The steel is now not nearly overoxidized to the same degree in the open hearth as the late Dr. Heroult thought to be necessary.

Dr. Lindsay referred to the largest cold-charge electric steel plant now in course of construction by the Canadian Government at Toronto, where ten Heroult furnaces of 6 tons each will be employed for cold melting for the production of shell steel.

Dr. Richards referred to the still more ambitious project of the U. S. Steel Corporation for the South Chicago plant. This will not be, however, for cold melting. It will comprise Bessemer converters, two 250-ton open-hearth furnaces, and ten electric furnaces of 30 tons' capacity each. The steel will be transferred from the Bessemer converters to the open hearths (serving as reservoirs) and finally to the electric furnaces. The total capacity of this triplex process will be 50,000 tons of steel per month.

The Electric Furnace in the Steel Casting Plant

Mr. R. F. Flinterman, president of the Michigan Steel Castings Company, Detroit, Mich., then presented his paper on the above subject. This is herewith reproduced practically in full.

Under the term "small steel castings" is meant castings used for the most part for automobile trucks, tractors, light machinery parts, and for other purposes, where the size and shape of the part, its lightness of section or difficulty of production preclude its being made practically in open-hearth foundries. In the latter, the work is largely a tonnage proposition. The work is much heavier and on the whole simpler and the methods used cannot be applied successfully to the manufacture of lighter and more intricate castings.

The castings the author's plant has been manufacturing run from ½ lb. up to 250 or 300 lb. They do make some pieces running up to 2000 lb., but the average weight is about 20 lb.

Before installing the electric furnace they employed the crucible furnace. This was chosen because of the low first cost of installation and also because of the generally accepted fact that crucible castings were of very high quality.

The great difficulty with the crucible process was in the crucibles themselves, in their lack of uniformity and high cost. An average of 3 heats was considered good and at that rate meant about 1 cent added to the metal cost. Many crucibles would not come up to this average

and in order to save them as much as possible the final addition of ferrosilicon and ferromanganese was cut down to a minimum. The result was a steel of low manganese contents, about 0.4 per cent, and as a consequence a steel which was not always deoxidized. The inability to keep the carbon low, because of the absorption of carbon from the crucible was an added aggravation.

Their second method was the side-blown Tropenas converter. Its advantages over the crucible are:

1. Large unit of capacity, converters of 1 ton and 2 ton capacity being used.

2. The metal was uniformly hot and fluid and of fairly regular analysis.

3. Possibility of increasing manganese content and consequently getting very much better results on physical tests.

4. Great reduction of metal cost. The cost varied little from month to month while in the crucible process the cost depended entirely on crucible performance over which they had no control.

Their third and "very likely final choice" was the electric furnace. The Heroult type was decided on and the first furnace of 6-ton capacity was installed in November, 1915. The second furnace of 3-ton capacity was ready to run Feb. 12, 1916. Both furnaces have been running continuously since their installation and the converters have been discarded.

It required several months to adapt the electric furnaces to shop conditions. This has, however, long since been accomplished and the furnaces have come up to expectations most completely. As regards the quality, there is no question of the superiority of the electric steel over converter metals. This applies to both acid and basic electric steel.

"It is only natural that this should be so if you compare the two methods. In the converter at the end of the blow there is a mass of metal at a high temperature, covered by a highly oxidized slag and the metal itself undoubtedly contains oxides. The addition of ferrosilicon and ferromanganese at this point deoxidizes the metal more or less completely, but the metal is still in contact with a slag carrying a high percentage of iron oxides, etc.

"In the electric furnace the covering slag is completely deoxidized before ferrosilicon and ferromanganese final additions are made. The metal is constantly giving up oxides to the slag during the deoxidizing period and is practically free from oxides before the final deoxidizers are added.

"In our opinion it is the more complete absence of oxides in the electric steel, which accounts for the superiority of this steel over converter steel. The results obtained on physical tests are universally better."

Typical test results are given in Table I.

	Maximum Strength, Lbs.	Elastic Limit, Lbs.	Per Cent Reduc- tion in Area	Per Cent Elonga- tion in 2 In.	S.	P.	Mn.	C.
1....	66,750	42,500	51.7	35	.23	.025	.044	.74 .19
2....	76,000	45,000	45.8	30	.20	.021	.040	.64 .23
3....	62,400	36,500	50.0	32	.27	.043	.036	.52 .19
4....	69,000	37,500	40.0	28	.33	.050	.056	.70 .24

Steels 1 and 2 are from the basic furnace and 3 and 4 from the acid furnace. While the basic steel averages slightly higher than the acid steel, they are both very much better than the average results that were obtained from converter steel.

The great superiority of the electric steel lies in the fact that these results can be consistently obtained from every heat which they were never able to do in

converter practice. "We have made physical tests on 30 consecutive heats and have for every heat obtained results corresponding to the sample given. With the converter steel we had great difficulty in maintaining an average reduction of area of 25 per cent and the elongation was usually about 20 per cent."

The superiority of the electric steel was also manifested in the case of long, thin-section castings, such as cross-members on engine supports. The loss due to shrink tears was much reduced with electric steel. On one particular pattern they made 100 castings from electric steel and found no shrink tears whatever. With exactly the same practice and pattern they found that 90 out of 100 castings made from converter steel had slight tears or cracks, which had to be welded in order to save the castings. This particular casting was very difficult to make and was perhaps an extreme case, but the test made brought out this difference in behavior most vividly.

The reason for this behavior is due to 2 facts:

1. The lower sulphur content of electric steel.

2. The absence of impurities, particularly of oxides. This resulted in much greater strength at high temperature and this greater strength was able to resist the pull, exerted on the steel during that period, when the castings were shrinking or shortening. This behavior of electric steel was true with both acid and basic steel, particularly with the latter, when a lower sulphur could be maintained.

The high quality of the electric steel was the one essential point which induced them to abandon the converter process in favor of the electric furnace. The hopes in this regard have been most fully realized. The time seems now at hand when this fact will be fully realized by the trade at large, as is evidenced by the increasing demand for electric steel. (Mr. Flinterman here remarked in parenthesis that since writing the paper he had received a contract specifying particularly that electric steel must be used.)

It was particularly pleasing to have the high quality steel without any increase in cost. Under present market conditions, with low-phosphorus pig iron selling at an exorbitant price, the electric steel can be produced at much lower cost than converter steel. "As our practice improves we feel confident that we can compete with converter steel even under normal market conditions."

At the present time they are using acid linings and bottoms entirely. The reasons for abandoning the basic process was the high and prohibitive price of magnesite. They were new consumers for this refractory and had not been able to secure a large supply, since the dealers were loathe to take on new customers and they were finally obliged to resort to acid practice.

This experience has been most valuable since one very great advantage was found in the acid process. One great difficulty with the basic process is the slag. The metal was poured from the furnace into a large coffee spout ladle in which the metal was taken to the pouring floors. The metal was poured through a spout into hand shanks, from which it was poured into molds. In all cases the metal was skimmed by means of a metal rod skimmer, while it was being poured into molds, in order to keep all slag back and prevent its entering the molds. In spite of all precautions there was much more trouble from slag in the castings than they had ever had from converter steel.

With exactly the same methods this slag trouble disappeared with the change to acid steel. This was due to the greater refractoriness or higher melting point of the siliceous slag, which brought about a more complete separation of the slag from the metal.

The basic metal acted at times as though there were actually present in the metal a small amount of slag in solution which slag would finally separate as the metal lost its heat. In a number of tests which were made when special precautions were taken to remove slag from metal, during pouring of molds, they still found slag spots on the machined surfaces of the castings.

As already stated, with acid steel there was a minimum of slag trouble. This has led to the conclusion that an ideal arrangement for a steel foundry would be to use a "reversed duplexing process," as it were. Part of the metal should be melted in a basic furnace, where the metal would be refined and sulphur and phosphorus eliminated in the usual way. The stock used in this furnace should be of a much cheaper grade and would more than offset the increased cost of rehandling the refined metal through the acid furnace as the next step in the operation.

In the meantime the acid furnace has been working on a partial charge of steel, to which when molten will be added the refined metal from the basic furnace. The final deoxidation under an acid slag can then be completed and metal withdrawn in the same manner as is done now. The author believes fully that this "reversed duplexing" can be so timed and manipulated in two or more furnaces that the ultimate output of the battery of furnaces will be the same in any given period as though the furnaces were all running either basic or acid independently.

This method of "reversed duplexing" would have several distinct advantages for the producer of steel castings, namely:

1. The cost of part of the raw material would be much lower, since a high sulphur and high phosphorus stock can be used, as for instance screw machine turnings, which bring a low price on the market and cannot be used in acid practice.

2. The basic furnace could be run at a lower temperature during refining period and the life of roof and walls would be much prolonged. The final temperature could be attained in the acid furnace, where there is no difficulty in securing necessary temperature and fluidity without injury to lining. They have run up to 300 heats without repairing roof or lining. (Mr. Flinterman remarked here that on the day before the meeting a roof had been taken down after having stood for 360 heats.)

3. It would be possible to obtain lower sulphur and phosphorus in the acid steel without increase in cost, in fact the finished cost might even be less.

4. The metal would receive final deoxidation under an acid slag. The advantage of this acid slag has already been emphasized, particularly the fact that the slag is more refractory and separates more completely. There is one further advantage. When the furnace contents are poured into the large ladle, the latter is immediately covered over with a congealed heavy slag crust, which keeps the air away from the steel and also keeps the steel hot longer. This is of great help in pouring a large variety of small castings, when fluidity and high temperature are most essential.

The author believes this "reversed duplexing process" may be of great value in other products such as tool steel, piano wire, etc., where the absence of even minute slag particles is most desirable. It would be interesting to conduct a comparative test on the products named above, made in the ordinary way and made by this double process. The suggestion may not seem so far-fetched when one bears in mind the fact that the higher grades of steel wire were until very recently made by crucible process, and in this process the slag was essentially an acid slag. How much of the quality possessed by these steels was due to the acid slag?

One other advantage of the electric furnace should be mentioned, namely its great usefulness in making any of the alloys. This has been demonstrated by the constantly increasing adoption of the electric furnace by tool steel producers and other makers of special steel. This same advantage can also be put to use by manufacturers of steel castings in the production of alloy steel castings.

The author's experiences in making alloys in the converter process was most unsatisfactory, since they were unable to obtain consistent results. This was due, no doubt, to the highly oxidized slag and presence of oxides in the steel itself, so that in many cases the alloying metals were oxidized and would be present in the final metals in varying and diminished quantities. With the electric steel the results have been very much gratifying. They have been able to obtain any desired analysis regularly, and in consequence the subsequent heat treatments have given them the high physical qualities which they were after. This opens up a large new field for the maker of small castings, since there is a large demand for alloy castings for certain purposes, where lightness and great strength and thoroughness are necessary.

As an illustration the author exhibited a very difficult manganese steel casting which they had successfully made.

In closing, the author called attention to one fallacy so often mentioned in discussion of electric steel, namely, that "electric steel is free from blow holes." He referred to the article on hydroelectric power and electrochemistry in France by C. O. Mailloux, the second installment of which appeared in the March 15, 1917, issue of *Met. & Chem. Eng'g.* It contained a quotation from an article by Girod in 1912 that "with the electric furnace one is sure to have for castings an absolutely dense metal without blow holes or pipes." Or to go even further back, in an article appearing in 1907, in *Stahl und Eisen*, written by Professor Eichhoff of Charlottenburg on progress in electric steel manufacture one of the conclusions was, "dass der Stahl vollständig blasenfrei ist."

"Every producer of steel castings wishes that this might be true. Without doubt the electric steel is purer and in consequence has within itself a minimum of impurities which during the transition from the molten state to a solid mass, would assume a gaseous form and cause blow holes. This much is granted as true. But nevertheless there is just as much cause for presence of blow holes in electric steel where the metal is poured into molds, as when the metal is made by other methods. The cause for such blow holes is not inherent in the steel itself, but is due to the methods of making the mold and preparing it for the steel.

"In other words, just as much care must be used in molding to make a good casting, in order to maintain in the casting the high quality and strength possessed by the electric steel. Perhaps even greater care and vigilance must be used because of the very high temperature at which the steel is delivered from the electric furnace.

"We have merely brought up to this point in order to emphasize the fact that the electric furnace is not a cure-all for all foundry woes and trouble. To make a superior casting, the electric furnace metal must have a perfect mold, prepared with every possible care and attention to detail, properly gated, properly fed and properly vented. When such a happy combination has been properly brought about, the resultant casting will be superior, and in this manner only and by no other methods can we derive the full benefit of the wonderful quality possessed by electric steel."

Mr. Flinterman's paper was discussed by Messrs. Fuller, Turnbull, Dixon, Fitz Gerald, Richards and Campbell. With respect to the difficulty due to getting basic slag inclosures in the steel, Mr. Dixon said that the basic slag should not strike the ladle before the steel does. With the acid furnace there is no trouble due to "liming" vapors attacking the silica roof. Further, the acid slag is a much poorer thermal conductor.

Dr. Richards had sent out an inquiry to 40 or 50 practical steel men as to how it is possible to get better and more reliable steel castings, and the recommendation made in 19 out of 20 answers had been to specify electric-furnace steel castings. This is significant.

Professor Campbell of the University of Michigan discussed very interestingly how our knowledge of the constitution of steel could be furthered by a study of the solubility of different slags in steel. Possibly a basic slag might be more soluble in steel than an acid slag; in that case the slag would be in true solution in the steel in a basic open hearth or basic electric furnace, while in an acid furnace the slag might be in mechanical suspension. Following out this hypothesis, it might be that with a basic slag a steel containing extremely finely divided sharp particles of slag would be obtained; this would be extremely bad for dies, for instance. If, however, the steel was transferred from the basic furnace to an acid furnace for a sufficient length of time, the slag may be separated out.

Electric Steel Melting

A paper entitled "Notes on Electric Steel Melting," by J. L. Dixon, of the John A. Crowley Co. (owners of the American patent rights of the Groenwall-Dixon furnace) first dealt with mechanical and electrical considerations of furnace design.

Mechanically, great strength is required. Especially the moving parts of the furnace mechanism, such as the tilting gear and the electrode-raising gears, should be of rugged design so as to withstand the rough usage and lack of attention they will receive in the average foundry.

As regards these gears, however, there are other considerations in addition to the purely mechanical ones. The design and location of these gears must be such that they are fully protected from any accidental break-out or overflow of liquid metal. With all possible precautions, break-outs or overflows will occur and it takes only a few pounds of liquid steel to put a lifting screw or a worm gear out of business. The protection of the electrode-raising gears is generally quite a simple matter, but not so with the tilting gear. In the Groenwall-Dixon furnace (page 568) a tilting gear giving excellent results mechanically has been abandoned owing to the danger of the gear being damaged by liquid metal. The danger may be very small, but any improvements in this direction will immediately show almost unexpected benefits, owing to the fact that the furnace operators are relieved of an unnecessary anxiety.

Another essential, perhaps the most important, is to avoid too great intricacy. This remark applies in some measure to all parts of the furnace, but more especially to the parts comprising the electrode contacts and supporting devices. With the best possible design and care the insulating materials will occasionally fail. If the parts are water-cooled a breakdown may result from a failure of the water system, due perhaps to an interruption of the supply. The writer recently had an experience of this, owing to a laborer turning the wrong valve.

Whatever the cause of the breakdown it is certainly unpleasant to have to stand on the roof of a hot fur-

nace and endeavor to remove the broken-down part, either by unbolting or by cutting it away with a hacksaw.

In designing a very large electric furnace requiring a large number of electrodes the difficulties may be overcome by suspending the electrodes from an overhead device quite independent of the shell of the furnace. This will certainly be the most convenient arrangement if the furnace is not tilting but is of the stationary type, as is quite probable with the very large furnaces that will come in the future.

Electrically the power factor is important and in a well-designed furnace the power factor should be 90 per cent or more. The power factor is improved by (1) an increased number of electrodes, more especially if they are all of different polarities, (2) by a higher voltage on the electrodes.

With respect to current fluctuations or overloads, again an increased number of electrodes is beneficial, owing to the spreading and averaging effect. A higher voltage on the electrodes tends to increase the fluctuations, but this may be largely overcome by reactance without seriously lowering the power factor. "It must be admitted that this question of current fluctuations and disturbances is often a very serious one, more especially with furnaces connected to small power stations, and the writer feels justified in saying that some radically new design in automatic controlling apparatus is necessary. The various kinds of apparatus in present use are of excellent workmanship, but in principle they do not go sufficiently to the roots of the trouble.

"Take, for example, the case of a three-phase furnace with three upper electrodes. When there is an overload on one of the electrodes, either one or both of the remaining electrodes are also overloaded, even though at that moment they are correctly located relative to the bath of metal. But the fact that they are correctly located is not observed by the automatic controlling apparatus which, acting under the impulse of the increased current, raises these electrodes, so that when the offending electrode is brought to its correct position the unoffending electrodes are carrying currents that are too small. In this way a more or less continuous hunting is set up and partly on account of this the automatic controlling apparatus has to be 'damped,' which lessens its sensitiveness and ability to deal quickly with any real trouble that may occur."

The author believes that furnaces with a bottom electrode are more easily controlled than those without, because any fluctuation of current in one of the upper electrodes is partly taken care of by the bottom connection instead of being absorbed entirely by its remaining upper electrodes. In this way the hunting due to what may be called false regulation is to a large extent avoided.

The author then took up thermal considerations and advocated the highest possible voltage for melting down the charge. Obviously the higher the voltage the smaller may be the electrodes and the higher will be the power factor. With furnaces of ten tons' capacity and upward, a voltage higher than usual has been found to be absolutely essential, but even in smaller furnaces there are advantages in this respect not directly attributable to the smaller resistance or induction losses.

During the refining period it is essential that the voltage be lowered so that the arc becomes practically buried in the slag. This is especially essential if a white deoxidized slag is obtained, as such a slag is a good heat insulator and reflector and the heat of the long arc will be reflected onto the walls and roof of the furnace.

The author thinks that a lower electrode has a distinct value from a thermal point of view. On occasions

when he has operated a furnace without a lower electrode he has experienced greater difficulty in maintaining the furnace bottom in good shape and more especially in making high chrome steels has experienced difficulty in dissolving the alloy additions.

For the furnace bottom the writer has always obtained good results from either magnesite or dolomite tamped in with tar.

As regards the walls and roof, every one operating electric furnaces is aware that these receive their greatest punishment at the end of a heat. This no doubt is largely due to the reflecting power of the white slag. In addition to this, however, the writer is inclined to believe that there is some chemical influence very active at that time. As is well known, silica bricks absorb mechanically occluded iron oxide (Fe_2O_3); at the end of the heat when the atmosphere of the furnace is strongly reducing the Fe_2O_3 is reduced to FeO , which at once fluxes with the silica. Perhaps, unlike the writer, some of the members have had an opportunity of trying clay bricks, which should be less sensitive to chemical influence than are silica bricks.

Finally discussing chemical considerations, the author says that the acknowledged advantages of a white slag are sometimes attributed to the strongly reducing effects of calcium carbide. The writer is inclined to disagree in this, and to attribute the good results not to the presence of calcium carbide but to the absence of reducible oxides, the presence of the carbide being merely a symptom that the deoxidation is approaching completion. It is obvious that, as a result of chemical equilibrium, if there is no oxide in the slag there can be very little in the metal.

"The writer is unaware that the mechanism of the reactions by which sulphur is eliminated has ever been described. He believes the reactions to be somewhat as follows:

FeS in metal

(a) $\frac{\text{FeS in slag}}{\text{FeS in metal}} = \text{constant}$

FeS in slag

"Disregarding the presence of manganese, the only way in which the amount of sulphur (FeS) in the metal may be adjusted is by some alteration of the proportion of FeS in the slag. An increase or decrease of any other sulphide in the slag will have no direct effect on the amount of sulphur in the metal. This is because any other sulphide, in this case CaS , is insoluble in the metal. In the slag itself the following equilibrium is established:

(b) $\text{CaO} + \text{FeS} \rightleftharpoons \text{CaS} + \text{FeO}$

"This may be written as follows:

$\text{CaO} \times \text{FeS}$

(c) $\frac{\text{CaS} \times \text{FeO}}{\text{CaO} \times \text{FeS}} = \text{constant}$

$\text{CaS} \times \text{FeO}$

"From this it follows that any decrease in the FeO in the slag will cause a decrease in the FeS , until when the slag is free from FeO all the sulphur exists as CaS . Referring to equation (a) it follows that when there is no FeS in slag there is no sulphur in the metal. Probably the slag might consist of CaS entirely without affecting the steel in any way.

"Something might be said as to the effect of magnesia in the slag. MgO in the slag is generally recognized to be very undesirable. At the best the MgO dilutes the slag and also robs it of fluidity, so that for a given degree of fluidity an increase in the proportion of MgO means a much greater decrease in the proportion of the active constituent, CaO . In addition to this, however, it would appear that MgO is actively harmful, and the writer believes that under the electric arc it acts as an oxidizer.

"Several years ago when burning in a magnesite bot-

tom by lowering the electrodes onto a shallow bed of coke, it was found that whenever the arc came near to the magnesite bottom deep channels were cut in the bottom. It was apparent that the following reaction was going on between the coke and the magnesite:



"Directly the vapors of $\text{CO} + \text{Mg}$ got away into the cooler parts of the furnace the reaction was reversed and there was deposited on the walls of the furnace a powder consisting of finely powdered MgO and soot.

"Possibly some reaction similar to this goes on between the MgO in the slag and the carbon in the steel and the carbon, such as coke, thrown onto slag for deoxidizing. Also it is possible that MgO reacts with metallic iron, forming Mg which is lost by volatilization and later reoxidation, leaving FeO in the slag.

"The writer remembers with painful distinctness several heats in which the carbon could not be moved from about 0.10 per cent. Pig iron was added with no effect, about a ton of pig being added to a five-ton charge. No scale or ore had been charged, and the disappearance of the carbon could only be explained by some of the above assumptions as to the action of the magnesia in the slag.

"These experiences were of several years ago, and by fettling the hearth of the furnace with good dolomite and making the slag from fairly pure lime, the difficulties were soon overcome."

Mr. Dixon's paper was discussed at considerable length by Messrs. Fitz Gerald, Turnbull, Seede and Stone. The special point of discussion was electrode regulation, and Mr. Turnbull (representing the Thury regulator) and Mr. Seede (representing the Seede regulator of the General Electric Co.) thought there was not enough collaboration between electric steel manufacturers and the manufacturers of electrode regulators. Mr. Turnbull said that contact devices have always been made of copper. But lately cast-steel holders have been introduced and cast-iron roof cooling rings have been in use for over a year; he recommends their use, at least for 25 cycles.

Mr. Stone said the central station's chief objection to electric furnaces is that in view of their large size, compared with motors, it is necessary to isolate an electric furnace installation completely from the rest of the system, beginning at the power plant. This is necessary with motors only in exceptional cases for large capacities. Equalizing the load as much as possible over 24 hours will be an advantage to the central station and will reduce the cost of power.

The Bethlehem 10-Ton Girod Steel Furnace

A paper by C. A. Buck, of the Bethlehem Steel Co., described the 10-Ton Girod furnace now in operation at the Bethlehem Steel Company's plant in South Bethlehem, Pa. This furnace made its first heat May 16, 1916, and has made a fairly consistent run to date. Until Sept. 1 the furnace operated on single turn, but since then has been in continuous operation, except when down for repairs or power. To Feb. 23rd, 247 heats have been made, and the quality of steel produced has been gradually improved.

The furnace is cylindrical in form and made of $\frac{3}{4}$ -in. (1.9 cm.) steel plate, approximately 15 ft. (4.5 m.) in diameter and 5 ft. (1.5 m.) outside depth, with laminated outside plates, $\frac{3}{4}$ in. (1.9 cm.) thick. It is equipped with one heavily laden, counterbalanced charging door, sliding in a water-cooled frame. The pouring spout is directly opposite. On the side of the shell heavy copper angles are attached to which are electrically connected laminated copper bars conveying current from the transformers.

The furnace rests on heavy cast-iron rockers running on rollers supported by rocker frames anchored to concrete foundation. The tilting of the furnace is accomplished by means of worm drive, actuated by a 15-hp. motor. The furnace can be tilted toward the charging side to discharge the slag through a notch in the charging door, or toward the pouring side to pour the molten metal into a 12½-ton ladle located in the pit in front of the furnace. The bottom, 20 in. (50 cm.) in thickness, is made of double-burnt dolomite well rammed in with tar. The metal bath is approximately 16 in. (40 cm.) thick.

Fourteen soft-steel poles approximately 3½ in. (9 cm.) in diameter are connected electrically to the bottom of the furnace shell, the lower ends being water cooled. The roof construction, which is arched, consists of 9-in. (23 cm.) silica brick, insulated from the magnesite brick of the hearth walls by means of asbestos plates, with provision for reception of three 17-in. (43 cm.) amorphous carbon electrodes. The electrode coolers in the roof are made of copper and are water cooled.

Ample provision has been made for adjustment, so that electrodes can be adjusted and centered firmly and speedily. Two laminated copper bars carry the current from the transformer to the contact pieces extending from the electrode carrier. The lowest point of an electrode during operation of the furnace is approximately 4 in. (10 cm.) above the surface of the metal bath.

The electrodes are raised and lowered by means of a revolving screw spindle centered in the structural column, which is driven by a 5-hp. motor, mounted at the foot of the column, or, if necessary, it can be operated by means of a hand wheel. The total weight of one electrode-carrying column is approximately 2600 lb. (1180 kg.) the weight of an electrode being about 1000 lb. (450 kg.).

The motors employed for this work are reversible, interpole type, using direct current at 230 volts, equipped with automatic speed regulation. The total weight of the furnace is approximately 90 gross tons, which includes about 35 tons of refractories.

About 1500 kva. of 3-phase alternating current, 25 cycles, 65 to 80 volts, is furnished to the electric furnace, each electrode receiving one phase of a 3-phase current, the conducting hearth of the shell acting as the neutral point. Special care has been taken to prevent the formation of induced currents in the shell and the roof frame, and to prevent sparking from the bus bars at the lower end of the electrode-carrying column to that column in electrical contact with the shell.

The current is conveyed to the furnace from three water-cooled single-phase transformers of 700 kva. each. It is generated by Bethlehem gas engines driving 2500-kw. generators, producing 3-phase alternating current of 6600 volts at 25 cycles. One reactance coil of 106 kva. capacity has been provided for the protection of each transformer. A special controller for each electrode is mounted in front of the switchboard, and one controller is provided near the pouring spout for the operation of the tilting motor.

Of the 700 kva. leaving the three transformers, about 620 kva. actually reach the electrode holder, the balance being lost in the form of heat through water cooling, etc. The consumption of cooling water at the furnace is about 20 gallons (75 liters) per minute.

The yield from cold charge to finished ingots is about 92 per cent.

A thoroughly equipped laboratory erected for the open-hearth department, which is adjacent to the electric furnace department, takes care of the necessary testing of the steel, etc. The electric furnace will be-

come a valuable adjunct to the Bessemer converter and the open-hearth furnaces, as a means of refining their molten product.

It is believed that the greatest field for this grade of steel will be in the alloy steel market and for many grades of tool steels. Thus far the following steels have been made: 1.5, 2.5, 3.5 per cent nickel, nickel chrome with 0.50 chromium, chromium vanadium, and simple carbon steels ranging from 0.08 to 1.30 per cent carbon.

The materials used for steel making are as follows: Scrap rails, high-phosphorus turnings, billet crop-ends, drop-forge trimmings, etc., which mixture should average 0.040 sulphur.

The operation of the furnace is very similar to that of the basic open hearth. Following the tapping of a heat, turnings are charged and leveled down. Any necessary repairs along the slag line are made with dolomite. Billets or other heavy scrap are next charged, followed by turnings until the entire 21,000 lb. (9550 kg.) charge is in the furnace. Lime is then added, current turned on, and melting is begun. Much of the phosphorus is removed through combustion, carbon is reduced by oxidation, and some of the sulphur is removed. The length of time required for the oxidation is dependent upon the carbon and phosphorus content of the charge.

When it is considered that the oxidation has proceeded far enough, a test about 2.5 in. (6 cm.) diam. and 2 in. (5 cm.) long is taken, forged under a hammer, quenched in water and bent through 180 degrees. When the test bends without breaking through the bend, the oxidizing slag is removed by tilting the furnace backward and skimming off slag through the charging door. Slag flows through a chute in the charging floor into a slag car under the floor.

Following removal of the oxidizing slag, the recarburizer is added, followed by the deoxidizing slag of powdered petroleum coke, silica sand, lime and fluor-spar. This slag dissolves ferrous oxide which has formed on the surface of the bath.

A reasonable time after the addition of the deoxidizing slag a test is taken for the laboratory for carbon determination. Varying amounts of ferro-silicon, ferro-manganese, etc., are added to bring the slag to the point where it becomes white, and quickly disintegrates into a fine white powder. These alloys act very energetically on the oxide in the bath, forming a very fluid slag, which easily rises to the surface. During this period, when the slag is completely deoxidized and is very basic, the desulphurization, which was incomplete during the first stage of the operation, proceeds further, and is rapidly completed at the time of tapping.

The average analysis of the preliminary tests taken after the charge is melted and before removal of oxidizing slag is as follows:

C. 0.07 Mn. 0.11 P. 0.008 S. 0.036 Si. 0.022
The analysis of oxidizing slag from heat Y-1219, a high-carbon simple steel heat, and of the finishing slag at time of tapping showed:

	Oxidizing Slag.	Finishing Slag.
SiO ₂	8.89	6.49
FeO	36.82	1.26
MnO	4.71	0.16
CaO	35.26	69.83
MgO	9.25	2.61
P ₂ O ₅	0.705	0.092
S	0.19	0.34

This heat finished with phosphorus 0.010 and sulphur 0.016.

Several heats have been made since this one analyzing below 0.010 P. and 0.015 S.

All of these heats are entirely satisfactory from a

metallurgical standpoint. The ingots rolled well, and in many cases it was not necessary to chip a single billet.

Nearly all of the heats thus far have been cast in 19 x 19 in. (48 x 48 cm.) x 6000 lb. (2730 kg.) or 21 x 27 in. (53 x 68 cm.) x 12,000 lb. (5550 kg.) ingots, and the practice on the 35 in. (88 cm.) bloomer mill on the various grades has been from 75 to 82 per cent.

Mr. Buck's paper, which in the absence of the author had been presented by Dr. Richards, was briefly discussed.

Electric Characteristics of Electric Furnaces

A very elaborate paper on this subject was then presented by A. A. Meyer of the Detroit Edison Co., giving the results of an electrical investigation of a Heroult and of a Grönwall electric steel furnace, covering their construction, operation, load fluctuations, power factors, unbalancing effects on the three-phase system, and determining the wave distortion by the oscillograph. The oscillograph data are studied closely, to draw from them deductions as to the self-induction of the furnace and connections. The effect of these considerations on the accuracy of the customer's watt-hour meters is also discussed.

The paper, which is probably the first of its kind in the elaborateness of the research of this subject, will deserve close study in all details by electrical engineers specializing in electric furnaces. It was discussed at some length by Messrs. St. John, Seede, Flinterman, Cavanagh, Baur and Richards.

Rennerfelt Electric Furnace Operation

Mr. C. H. vom Baur, with Messrs. Hamilton and Hansell, read a paper giving further information on the Rennerfelt electric furnace, supplementary to his former paper (our Vol. XIV, p. 479, May 1, 1916). The principal improvements, since made, are as follows:

1. The furnace hearth is now circular, with one set of electrodes, and oval shaped with two sets.
2. The side electrodes are adjustable in a vertical plane, allowing them to dip toward the bath.
3. The available power, or instantaneous available heat, has been largely increased.

The operating results obtained in making these three changes have not only kept up the quality of the steel, but the cost has been reduced materially. The reasons for this are quite apparent.

With a circular hearth and the flame in the center, the heat distribution is equal at the slag line; there are consequently no cold corners, obviating overheating when melting, which is so detrimental to both side-walls and roof. The side-walls, slag-line and roof, especially the latter, now dome-shaped, are easier to repair. Often, only the center portion of the roof bricks need replacing, the other roof bricks lasting twice as long.

The second feature, viz., tipping the side electrodes down from a horizontal position, has several advantages. When smaller charges than normal are made, the most efficient height over the metal when melted can be had. During melting, the electrodes at the start, whether for partial or full heats, are usually only an inch or so (2.5 cm.) over the bath. As the charge melts, the electrodes are continually lowered, thus keeping the flame about 2½ to 3 in. (6.2 to 7.5 cm.) over the bath. Bringing the flame closer to the bath accomplishes two things: the melted steel more readily absorbs the heat, and the large flame, being farther away from the roof, lengthens its life. This is proven by the shorter time to make a heat from a cold charge and by a longer life of the roof.

The possibility of tilting the electrodes up and down helps when slagging off, and lessens the breakage of electrodes.

The flame nearer the bath, and with the same potential, has a tendency to circulate the slag faster. This can easily be observed, and is of the greatest importance. A more shallow bath facilitates the refining, as the metal comes in contact with this slag on a larger surface.

The flame itself, depending on the size and electric power of the furnace, seems to make a circular patch on the thinned slag directly beneath the flame about 8 or 10 in. (20 to 25 cm.) in diameter, and then mushrooms out. The hotter the furnace, the better the conductivity of the gases and the greater the spreading of the flame. In a two-flame furnace, this flame at times seems to spread over the entire bath. This appearance is, no doubt, due to incandescent gas. The hearth is made more shallow, and thus the rammed-in bottom coming up at the sides makes the sides less steep. This shallow bath shortens the time of melting down, and the lining is less affected at the slag line.

The regulation of the heat applied to the bath is made easier by the variable position of the flame above it, and it also lessens the danger of overheating, which is apt to become so detrimental with an acid bottom. The almost invariably clean steel produced, with the absence of inclusions, is obtained by careful handling, yet the ease of avoiding overheating is of first importance. Metallurgists who have operated the Rennerfelt furnace have particularly noted this length point, and the avoidance of worry which thus ensues.

Having the electrode tips never more than 3 in. (7.5 cm.) above the bath, has materially reduced the time of melting (so far no Rennerfelt furnace in the United States is using fluid charges). With basic bottom the dephosphorizing time has remained unchanged and the desulphurizing period, with the aid of calcium carbide slags, has been reduced. When refining and reducing sulphur with a built-up slag from ferro-silicon and lime, as used in the induction furnace, this was accomplished with good effect.

With furnaces having 300 kw. power per ton of output, heats have been made on basic bottoms, taking off one slag in 2½ hr. with 670 kw.-hr. per ton when operating continuously. With acid bottoms and 200 kw. power per ton of output, taking off one slag, good steel and full heats have come off in 3¼ hr., with 635 kw.-hr. per ton.

The electrode consumption is less than 6 lb. (3 kg.) per ton of steel made, operating continuously. Even with the present excessively high cost of refractories, their cost has been reduced in the smaller furnace of one ton from \$2.91 per ton of steel made to less than \$0.80 per ton. Roofs are lasting over 100 heats, and approximate the longer life made in Europe with better refractories. With a higher power input the heats are shortened, due to the smaller melting period (the heat being considerably reduced during the refining time), thus roofs are lasting more heats than formerly, though the actual time is not much changed. Side-walls of brick outlast two or more roofs, while the bottom lasts a year or two.

The third change, to higher powered furnaces, besides lowering the cost per ton in every way, steadies the consumption of electricity, which has already been very constant. For instance, a 3-ton furnace operating with 600 kw., with hand-regulated electrodes, will reduce in four or five minutes to about 550 kw. without any fluctuation (except during the first part of the melting period) and without touching the electrode regulating mechanism. With smaller furnaces the steadiness is not so marked, whereas with still larger ones, the effect is but little improved. The power factor is about 90 per cent, with 60 cycles. All sudden strains on the power supply are avoided. The arc voltage has been raised, and is now 110 to 120.

In general, too much stress cannot be laid on the various small details, such as tight doors, and tight openings around the electrode cooling boxes. With the latter, besides a small clearance between the cooling box and electrodes, asbestos washers help materially.

The paper was discussed by Messrs. Gillett, St. John, Bennett, Williamson and Richards.

The Grinding Wheel

Mr. R. G. Williams then read his paper on "The grinding wheel—a connecting link between the electric furnace and the automobile." It was illustrated by numerous lantern slides. The paper is published in full on page 599 of this issue.

The Smoke and Fume Problem

Two papers, formerly presented before the New York Section of the Society, were then read by title and briefly discussed. The first, by Ligon Johnson, on "The history and legal phases of the smoke problem," was published in full in our issue of Feb. 15 on page 199. The second, by W. W. Strong, on "Theoretical aspects of electrical fume precipitation," will be published in full in one of our next issues.

Chemistry of the Flaming Arc in Relation to Luminescence

The Friday morning session was opened with the presentation of a very elaborate paper by Wm. Roy Mott of the National Carbon Co. on the above subject. The paper is of very considerable interest both from the viewpoint of the flaming-arc manufacturer and from the viewpoint of analytical chemistry. The subject is discussed by the author in twelve chapters under the following headings: (1) Introduction; (2) comparison of carbon arc and flaming arc; (3) magnified arc image, apparatus and method; (4) color of arc parts for nearly all elements; (5) divided and diffused negative craters; (6) volatility and crater distance; (7) materials less volatile than carbon, pitting residues; (8) typical characteristics for analytical purposes; (9) four light sources due to reactions with calcium fluoride in arc; (10) effect of alkali salts on cyanogen bands; (11) results from the electrochemical standpoint; (12) conclusions.

The conclusions of the author are as follows:

There is no case of a blue arc shell.

In every case except Ba and V, the arc core is blue or violet and the shell green, yellow or red. Hence the hue of shell in every case except Ba and V is of a longer wave length than hue of arc core.

All the non-metallic elements (F, Cl, Br, I, O, S, N) give no elemental spectra, but F, Cl, O, N give some compound spectra in a carbon arc. Also the halogens with alkaline earths except Mg, many oxides, a few nitrides.

The intermediate elements, P, As, B, give no visible and only a few ultra-violet lines in the carbon arc.

The easily reduced metals (*i.e.*, easily electrolyzed in metallic form from aqueous solution) give no arc shell except the iron (magnetic) group of elements. The low energy of reaction at high temperatures explains this lack of light.

The most electropositive elements give the most marked colored luminous shells especially where more than one valence stage is characteristic of the element at high temperatures.

With yttrium oxide, the crater on the bead alone gives a green shell replacing the usual red, with crater partly on bead and on carbon.

Zirconium oxide gives a yellow-white shell. The yellow-white is probably due to hot solids, as zirconium

carbide is less volatile than platinum and its oxidation would give also extremely non-volatile oxide. Zirconium metal is fairly volatile.

In nearly every case with a carbon arc, the flow of material is from positive to negative. However, with the salts of K, Rb and Cs, there is in mixtures with for example calcium fluoride a strong blast which also comes from the negative crater causing a unique dimness near the negative part of arc.

A dim, large positive crater can often be produced by nearly all salts of K, Rb, Cs, and oxysalts of sodium. This with the effect on cyanogen bands and marked arc length may be explained by the reaction: $KF + 2(CN) = KCN + CNF$, and others necessary to return by oxidation to KF , CO , and N_2 .

A dim negative crater is most easily produced by barium salts volatilized from the positive. This as well as that with other materials is probably connected with nitrogen reactions at fairly high temperatures.

Beryllium oxide is the least volatile of the oxides which are so insulating as not to allow cratering, such as alkaline earth oxides, aluminium oxide, and silica.

The oxides of yttrium, zirconium, thorium and other rare earth elements allow cratering.

Tungsten is easily the least volatile of all known elements, with tantalum second.

The light sources of a yellow flame arc are due to reactions involving calcium fluoride, calcium oxide, calcium carbide and elemental calcium (lines), in addition to usual carbon arc light sources.

A simple cheap means of qualitative (and to some extent even quantitative) analysis is found in the magnified arc image. This enables much data on relative volatility to be quickly obtained.

Mr. Mott's paper, which was illustrated by some very instructive and interesting colored charts, was discussed by Messrs. Hinckley, Fink, Richards, Frary, and Lidburg.

The Vosmaer Phenomenon

A paper by Dr. W. C. Moore of the National Carbon Company, on "The Vosmaer Phenomenon," was then read by Mr. Mott in the author's absence. As the Vosmaer phenomenon was first described in this journal several years ago, we publish Dr. Moore's paper in full elsewhere in this issue.

In the discussion which followed, Dr. Fink said that this afforded a very simple method of testing metals and alloys for heat resistors. To produce the Vosmaer phenomenon, three conditions must combine: firstly, the envelop (nickel oxide in the case of the Vosmaer phenomenon) must not be soluble in the metal inside (nickel); secondly, it must have a higher boiling point, and thirdly a high surface tension.

Acid-Resisting Properties of Some Iron-Silicon Alloys

A paper on this subject, by Prof. O. L. Kowalke of the University of Wisconsin, was read in abstract, in the author's absence, by Dr. Watts.

Various acid-resisting alloys of commercial importance have been produced within recent years, and among these the iron-silicon alloys seem to give satisfactory service in many operations.

W. Guertler and G. Tammann¹ worked out the equilibrium diagram for these alloys. The curve shows mixed crystals or a solid solution of Fe and FeSi between 0 and 20 per cent silicon. At 20 and at 33.7 per cent silicon there are two compounds, Fe_2Si and $FeSi$ respectively, which combine to form a eutectic at about 21.4 per cent silicon. The compound $FeSi$ and free silicon form a eutectic at 60.6 per cent silicon, which corresponds to

¹Zeit. Anorg. Chem., 47, 163-179.

the formula FeSi . The melting point of FeSi is about 1250 deg. C. and that of FeSi about 1443 deg. C. The alloys made for this investigation lay in the region of mixed crystals, and did not contain over 20 per cent silicon.

The alloys were made from electrolytic iron and ferro-silicon which analyzed 49.5 per cent silicon; no test was made for carbon. Acheson graphite crucibles lined with magnesium oxide were used to melt the alloys. Each charge was made up to a total weight of 200 grams and the amount of ferro-silicon for each alloy was computed from the amount of silicon to be added. The charges were melted in the covered crucibles in a granular carbon resistor furnace.

The mold for casting the alloys was made from Acheson graphite.

The alloys were not stirred while in the furnace, but as the crucibles containing the fluid alloys were removed from the furnace they were given a gyratory motion so as to mix the molten charge thoroughly. The melted alloys were then poured from the crucibles into the molds.

Since the alloys cooled very rapidly upon being poured into the mold, there was undoubtedly a negligible amount of carbon absorbed, but no chemical analyses were made to prove this point.

The alloys of low silicon content made good soft castings. Above 3.5 per cent silicon the alloys were brittle. In alloys of 7.5 per cent silicon and above there were such severe strains developed on casting that they would frequently break into small pieces in the mold. Some alloys with more than 11 per cent silicon would fly apart with great violence. Two castings with 16 per cent and 17 per cent silicon broke in the acid during corrosion tests the second week after casting the same.

The acids used in the acid corrosion tests were 10 per cent solutions by weight of sulphuric, hydrochloric, nitric, acetic, and citric acids. The temperatures of the acids when made and when used in the tests were between 20 deg. and 25 deg. C.

The results of these tests are given in the original paper in form of a series of tables. The per cent loss is cumulative. The general results of the tests may be summed up as follows:

Sulphuric Acid: The loss is greatest at about 3.7 per cent silicon, then the resistance increases to a maximum with a silicon content of 16 per cent. Beyond this content of silicon the resistance seems to decrease.

Hydrochloric Acid: The loss is greatest at about 3.7 per cent silicon, and least at about 18 per cent silicon. Beyond this content of silicon there is a decrease in the resistance.

Nitric Acid: The loss diminishes quite steadily until the silicon content reaches 16 per cent, after which it increased.

Acetic Acid: The loss increases up to a content of silicon of about 5 per cent, beyond this point it decreases steadily to 16 per cent silicon, beyond which it again increases.

Citric Acid: The corrosion increases up to a content of 3.3 per cent silicon, beyond which it gradually decreases to the point where the silicon is 17 per cent.

The author's final conclusions are as follows:

Silicon-iron alloys of about 3 to 5 per cent silicon are attacked very readily by sulphuric, hydrochloric, acetic, and citric acids. These alloys are not excessively brittle.

Silicon-iron alloys of about 16 to 18 per cent are exceedingly resistant to action of sulphuric, hydrochloric, nitric, acetic, and citric acids. These alloys are so brittle that they must be ground; they can not be machined.

A solid solution of FeSi in iron near 20 per cent silicon is resistant to mineral acids.

Search is in progress for a third metal which can be added to the iron-silicon alloys to improve their strength and still retain the resistance to the action of acids.

The paper was discussed by Messrs. Burgess, Watts, Richards, Brooks and Mott.

Corrosion of Cast Iron

A paper by E. A. Richardson and L. T. Richardson on "The Corrosion of Cast Iron and Its Bearing Upon the Electrolytic Theory of Corrosion" was read in abstract by Dr. Richards in the authors' absence.

Cast iron has not been as extensively studied for its anti-corrosion properties as steel or pure iron. The authors think that being less pure and more heterogeneous than either of the latter, it should rust faster according to the electrolytic theory of corrosion. Three pieces of these three materials were exposed to rusting influences for seven months, then cleaned and weighed. Pure iron corroded least, cast iron 25 per cent more, and steel 100 per cent more. According to the authors, the electrolytic theory of corrosion does not explain these results.

The paper elicited quite an extended discussion. Dr. Hering thought that the authors do not interpret the electrolytic theory of corrosion correctly. Dr. Badger called attention to the fundamentally important paper by Heyn and Bauer. Mr. Fuller called attention to the advantageous addition of a small amount of copper to steel as another example of a heterogeneous substance with better resisting qualities.

Mr. Speller said that there is no material difference between cast iron and steel if a large enough number of samples are tested with the same finish. It would be dangerous to draw general conclusions from this paper. The composition of a steel has not so very much to do with corrosion nor does that involve the electrolytic theory of corrosion. Corrosion is essentially a surface reaction. For practical purposes it is very important to take into consideration that the products of initial corrosion may provide a mechanical protection against continuation of corrosion. This is, for instance, the case with copper-steel, where a protective oxide surface film is formed.

After some further remarks by Mr. Burgess and Mr. Schuler, a communicated discussion by Dr. Henry M. Howe was read pointing out that the results of the authors were not in conflict with the electrolytic theory of corrosion. Initial corrosion produces a surface of graphite which becomes protective.

Mr. Lidbury thought that too many workers on corrosion approach the subject with a wrong mental attitude. They are not looking at it as a many-sided complicated phenomenon, but are trying to find a single explanation.

Low-Temperature Electrothermal Processes

A very interesting paper on this subject was presented by C. F. Hirschfeld, chief of the Research Department of the Detroit Edison Company. As it relates to a broad subject that is bound to increase in importance from year to year we print the paper practically in full.

Those who have become familiar with the various uses of electric furnaces of one sort and another have come to recognize the fact that, in a general sense, the electric furnace can not be considered a commercial competitor of furnaces heated by combustion. The use of the electric furnace must make possible the attainment of something unattainable by combustion methods or else there is no possibility of its being used in place of the older type excepting, possibly, under very unusual conditions as to the relative costs of fuel and electrical energy.

If this is true of high-temperature processes such as are commonly associated with electric furnaces it needs no argument to prove it true for low-temperature processes in which combustion methods have a greater advantage on an energy cost basis, because of the lower temperatures at which the products of combustion can be discharged.

This condition is frankly admitted, and it should be understood at the start that it is not the intention of this paper to urge the general substitution of electric heating for combustion heating in low-temperature processes in general, or in some low-temperature processes exclusively. There are certain low-temperature processes which, under certain circumstances, can be conducted to better commercial advantage by means of electric heating than is possible by means of combustion heating, and it is the purpose of this paper to point out some of these processes, some of the phenomena connected therewith which indicate the advisability of heating electrically, and some of the possibilities which electric heating unfolds.

The term low temperature is not exact, but for present purposes may be taken as referring to temperatures below about 290 deg. C. (554 deg. Fahr.). Such temperatures are below practically all commercial metal-melting temperatures but are common in numerous baking and drying operations which form a surprisingly large part of industrial processes.

The exploitation of electric heating for such low temperatures in industrial practice is really comparatively old, since numerous small electrically heated appliances operating at such temperatures have been used as a matter of convenience in manufacturing establishments for a number of years. During the past few years, however, the use of electric heating for such temperatures has been adopted in cases calling for the installation of equipments with capacities ranging from several hundred to several thousand kilowatts. This is obviously a different sort of a proposition, and must be based on a far broader consideration than mere convenience.

ELECTRIC JAPANING OVEN

The best example of the extensive adoption of electric heating for low-temperature work is furnished by the electric japaning equipment installed during the past few years.

The name "japan" originally referred to a sort of liquid lacquer or varnish made from vegetable sources in Japan and used as a protective or decorative coating on objects made of wood and other materials. This original japan was converted into a hard, brilliant material by exposure to sunlight. At the present time the word japan is used as a sort of collective title for a number of paint-like materials which are intended to be baked at various temperatures between 100 deg. C. (212 deg. Fahr.) and 260 deg. C. (500 deg. Fahr.) and which are generally used for decorative or protective coatings on metal objects.

Originally, these baking japons were much like varnishes to which pigment had been added, but as the development of industry made more and more specific demands the number of japons manufactured was greatly increased and many different type formulas were adopted. At the present time one can purchase under the name "japan" materials varying all the way from combinations of pigments with driers, linseed oil and expensive gums to materials which are little more than Gilsonite or other asphaltic compound carried in a suitable solvent with enough oil or similar material to make it resilient after baking. Driers are often included in the mixture, but this is not a universal practice.

The changes which occur during the baking of these

japons are very complicated, and are not yet entirely analyzed from the scientific standpoint. It is certain that the solvent partly or wholly evaporates during the baking, and it is also certain that the oils and gums undergo oxidation and polymerization. It is also probable that complicated reactions occur between the numerous varieties of hydrocarbons and hydrocarbon derivatives present in the mixture.

The general lack of exact knowledge is shown by the fact that few, if any, makers of japan can predict the behavior of their materials under unusual conditions.

At the present time a number of chemists who have been specially trained in the technology of paints and varnishes are at work on japons, and it is probable that more exact information with regard to these materials will be available in the future.

When electric baking of japan was first considered a few years ago, it was found that practically all japaning practice was of an empirical character. Moreover, no two japanners seemed to agree upon the proper methods of applying and baking a given japan even when all essential variables, such as weight and character of work, were the same. Discussion of the various problems with many users and with many makers of japons brought out the fact that practically all agreed upon certain rules and regulations but that there was a large mass of so-called trade secrets which were, partly or wholly, mutually contradictory.

Obviously, this particular art had not yet progressed beyond the empirical state. Scientific analysis had not been extensively undertaken, no consistent mass of scientifically accurate facts had been accumulated, and operators were hired on the basis of a self-advertised collection of rules of thumb combined with most wonderful and weird imaginary charms of various sorts for insuring excellent results. The executives responsible for factory production were entirely at the mercy of these self-styled experts, some of whom were really remarkably clever men, but many of whom could really lay no claim to such a title.

It is not surprising that, under such conditions, the japaning room should have been a source of constant worry. On one day very satisfactory results were obtained, and on the next all sorts of imperfections appeared.

In many establishments an average rejection of as much as 10 per cent of the finished work was regarded as a characteristic of japaning processes and was taken as a matter of course. In some instances on record rejection of over 50 per cent for several days in succession occurred at irregular intervals.

Such facts indicate plainly to the trained observer that one of two conditions exists. Either the conditions necessary to insure completely satisfactory work are not known or else the control of the essential variables is imperfect. In the case under discussion both conditions seemed to exist and the methods in vogue made it so impossible to control the essential variables that little opportunity existed for studying in the field the effects produced by giving them different values.

As an example of the complications to be met consider the possibilities existing in any given case. Assume, for instance, a given japan used in connection with a given piece of material.

1. The japan may be thinned to various degrees, but there must be some value which will give the most satisfactory flow combined with proper covering of the article.

2. The japan may be maintained at a number of different temperatures during application, but there must be some japan temperature which will give the best results.

3. The material being covered may have a number of different temperatures when the japan is applied, but there must be some best value.

4. The length of time during which the material is allowed to drip or stand after the application of the japan may vary widely, but there must be some best time.

5. The temperature of the material and space during the interval between application and baking may have numerous constant or changing values, but there must be some best value.

6. The law of temperature rise during baking is capable of infinite variation, but there must be some best sequence of temperatures.

7. The law of temperature fall after the maximum baking temperature has been maintained for the requisite length of time is also capable of infinite variation, but there must be some best sequence.

8. The condition of the atmosphere, both with regard to contained moisture, contained japan vapors, and contained impurities or admixtures of various sorts, must have a decided effect and some best condition must be possible of attainment.

Admittedly the list of variables is formidable, but they are all of such character as to yield to simple experimental investigation. Unfortunately, the effects of practically all are overlapping, and a thorough investigation must therefore involve a great expenditure of time.

The application of electric heating to this art served the very useful purpose of making it possible to control accurately some of the variables, and the combination of electric heating with the continuous methods which were introduced with it made this control more extensive and automatic. With the combination of electric heating and continuous types of oven as now built, it is possible to control accurately and automatically all of the variables listed above. Therefore, if one piece of work is satisfactory all must be satisfactory, if they come to the japanning room in the same state of preparation and if they have the same characteristics as to quality of material, contour, distribution of mass, etc.

Much of the credit for the control attainable with electric heating must be given to the mobility of electric heating units. They can be shifted about with great ease until that particular arrangement which gives the best temperature distribution and best temperature gradient is discovered. After they are once located in such positions, the results attained are independent of all of the variables characteristic of combustion processes. Their performance must be the same not only day after day, but even year after year.

The ease and certainty with which electric heating units can be controlled automatically must also be given its full share of credit. The human factor with all of its inherent tendency toward forgetfulness and toward variation from time to time is absolutely eliminated by this method.

Since the introduction of continuous electrical methods it has been possible to make semi-scientific investigations in the industrial field, and several notable pieces of work have been done along these lines. As a result of one such investigation, the japanning in one large plant has been reduced to what is practically an absolute basis. In this case practically everything is controlled automatically and one individual located in front of an instrument board some distance from the ovens and out of sight of all operations has general supervision of the entire process and is responsible for results.

Certain interesting facts have been brought out in connection with the electrification of this art. It does not seem advisable to burden this paper with a dis-

cussion of all of them, and attention will therefore be confined to one set of facts which is particularly illuminating.

At the time when electrification started it was customary to bake japan in direct-fired gas ovens, in most plants. In these ovens gas is burned within the space in which the work is enclosed, and the products of combustion bake the work during the entire process. Temperatures of the order of 180 deg. C. (356 deg. Fahr.) were considered the maximum allowable, and from 1½ to 3 hours were required per bake. For good work, which was to show a fine finish and was to resist wear and weather, three or more coats were deemed necessary. It was found to be particularly difficult to be sure of obtaining a high gloss, and the weathering qualities of work made under what were supposed to be exactly similar conditions were remarkably diverse.

After many abortive efforts to find means of studying what actually occurred during baking it was decided to resort to the microscope, in the hope that surface structure might throw some light on the matter. The results obtained greatly exceeded anticipations.

Microphotographs showing typical structures resulting from baking japan are given in the paper. It is shown that from baking japan slowly in a direct-fired gas oven the formation of small craters results which seems to be typical of all baking methods in which the heating is done by means of hot gases bathing the work. It is possible that their occurrence may be explained by what may be called subsurface vaporization (as explained in greater detail in the original paper).

These craters are probably partly self-healing, as the process is ordinarily conducted, but the healing is not perfect. A collection of such craters is all that is necessary to account for poor gloss and poor weathering qualities.

On the other hand, microphotographs of work done in electric japanning ovens under otherwise identical conditions show that the electrically baked piece has smaller and more evenly distributed craters, and that the surface is more perfect. Other comparative photographs of second and third coats show far more perfect surfaces resulting from electric heating.

It is interesting to note that the baking of the coats in the gas oven consumed a total of five and a half hours while the three corresponding coats were baked electrically in two hours and forty minutes.

Inspection of pieces baked in direct-fired gas ovens and similar pieces baked in electrically heated ovens always shows that the electrically baked material has a higher and more perfect gloss or finish.

This could be accounted for by assuming some action between products of combustion and the japan itself, and some evidence seems to indicate such action under certain conditions. However, in view of the microphotographs already referred to and the explanation of the craters, it seems more likely that the difference is due to the way in which heat is applied.

As a matter of fact, practically all heat transferred to the work in a direct-fired gas oven is carried to it by hot gases, that is the transfer is by convection. In an electrically heated oven at least part of the heat is brought to the work in the same way because of the circulation of oven atmosphere set up by the presence of the heaters. The rest of the heat is transferred by radiation from the hot heaters, and it seems probable that the action of the heat received in this way is different from that received by convection. It is at least probable that radiant energy penetrates the japan coat to a considerable depth before being entirely absorbed and converted into heat, and this causes more rapid setting of the inner portions of that coat.

If the craters are due to the causes assumed above, it should be possible to eliminate them entirely by baking the japan in a reversed direction, that is, from the inside out. This can be done electrically by heating the metal itself either by the direct passage of current or by induced eddy currents.

Certain experiments were conducted on a small scale for the purpose of determining the relative effects of baking by pure convection, baking by combined radiation and convection and baking by heating of the metal itself. For this purpose similar samples, dipped in the same japan, were baked in bottles. For convection baking filtered air was heated in an electric oven to the proper temperature and was then drawn through a bottle in such a way as to make it bathe the enclosed sample. For combined convection and radiation, the sample was surrounded by electric heaters enclosed with it in a bottle, the volatiles being drawn off and circulation being maintained by means of a small laboratory pump. For baking by internal heating the bottle and its inclosed sample were suspended in an alternating magnetic field of sufficient intensity to give the desired temperature gradient. During baking volatiles were removed by a small laboratory pump as before.

Inspection showed the sample baked by convection heating to have the poorest surface and that baked by internal heating very obviously had the highest gloss and most perfect surface. It was hoped that reproductions of microphotographs of these samples could be given in this paper, but it was unfortunately impossible to prepare them in time for inclusion.

It is of particular interest to note that baking by internal heating is essentially an electrical method, and that it is far removed in every way from methods previously in use. It is further important to note that with this method a maximum metal temperature of the order of 170 deg. C. (333 deg. F.) and a bake of 15 minutes are perfectly capable of giving better results than can be obtained with external electric heating with 45-minute bake and a maximum temperature of 230 deg. C. (446 deg. F.). It also seems probable that one coat baked in this way will prove the equal of two or three baked by the older methods. The effect of all this upon energy charges for a given weight of metal baked is perfectly obvious.

It seems hardly necessary to discuss at greater length the various phases of the japanning art. It should be evident that electric heating opens up opportunities for improving the product and the production methods used in obtaining that product. It should also be evident that electric heating is capable of reducing factory operations in this field to so exact a procedure that accurate laboratory control is made possible. With industrial conditions brought to this point it becomes possible for research chemists to work to advantage toward the improvement of the japans themselves and toward the improvement of the methods of their utilization.

ELECTRIC BAKING OF FOUNDRY CORES

An equally promising field exists in foundry core rooms. The baking of foundry cores is at present a most haphazard process in the majority of foundries. A casual inspection of one batch of exactly similar cores will generally show colors varying from a light tan or even lemon yellow to a dark chocolate brown. One of the numerous varieties is certainly better than all the rest, and it would seem desirable to determine which one is the best for a given set of conditions and then to make all of them like it.

Preliminary experiments conducted for the purpose of discovering whether the essential properties of cores

varied as greatly as their colors gave most astounding results. Strength was taken as reference in this case, although admittedly it is only one of numerous properties which must be considered in defining a perfect core.

One set of experiments was made upon exactly similar cores, made of the same materials and tamped to the same extent. They were baked at different rates and also with different maximum temperatures. Curves of strength plotted against time of bake and also plotted against maximum temperatures were sharply domed in all cases, and showed variations of several hundred per cent in any one case. Samples of these cores were shown to experienced foundry men after rupture so that both exterior and interior were visible, and they picked out, as good, cores which had shown relative variations of over 100 per cent.

Another set of experiments were made to determine the effect of air circulation. Again a number of exactly similar cores were tested. Baking methods were alike in every respect excepting for the quantity of air drawn over the core during baking. Strength of core was plotted against quantity of air passed in unit time, and again a sharply domed curve was obtained. Apparently, excess air is detrimental, though not to the same extent as a deficiency of air. What is more important is the demonstration that some definite quantity of air gives the best results.

It seems probable that investigation will show that porosity, brittleness, character of surface, and all of the other properties which must be considered in connection with cores will be affected in some such way as strength has been shown to be affected by the variables studied. If this is true, it certainly seems as though the foundries which carefully study their production methods and costs will ultimately demand more perfect control of the core-baking process. When this time arrives it seems probable that electric heating will play a part similar to that which it has played in the japanning field during the past few years.

As a matter of fact, there are now in operation several electrically heated core-baking ovens, and their users all appear highly enthusiastic over the results attained.

The core problem appears to the author as one of the most promising fields for combined chemical and engineering investigation, and he feels certain that improvements such as those shown possible in japanning will appear insignificant in comparison with those which are possible of attainment in the core room.

Japanning and core baking have been used as examples because of the tremendous extent of both of these industries, and because it happens to be possible to record the results of a small amount of experimental work in both of these fields. It must not be assumed, however, that they represent the only possibilities for the application of electricity to low-temperature baking.

There are numerous other low-temperature baking processes, and the majority are in the same undeveloped state as are the two cited above. One very important field in which little has been done is the baking of food-stuffs, such as bread and other cereal products. Electric heating has been applied to the baking of such materials in several cases with very gratifying results, improving both the appearance and quality of the product.

In conclusion, it is well to call attention to the fact that the introduction of electrical methods for such purposes as enumerated above should be of particular interest to the chemist, because it makes it possible to reproduce on an industrial scale a sequence of operations and conditions which have been worked out on a small scale in the laboratory. It makes it possible to

control industrial production to the same extent that laboratory investigations are controllable, and it thus opens to the chemist in the industrial field a tremendous opportunity for improvement of product and increased production.

Professor Hirshfeld's paper elicited a long and animated discussion which could not be finished in the Friday session and was taken up again in the Saturday session.

The discussion was opened by Mr. Lidbury, who emphasized the enormous importance of the subject. Efficiency and cost of energy are in low-temperature reactions of far less importance than convenience. For carrying out many chemical reactions electric heating is best. A lot more should be done by electric companies to further electric heating. The electric heating art is not in good shape.

Dr. Hering emphasized that in the study of drying problems it is important to consider the saturation of the surrounding atmosphere. Internal heating may be very difficult in cases, for instance, of certain automobile parts when the direct passage of a current through the part to be heated is impracticable and recourse would have to be had to hysteresis and eddy-current heating.

Mr. W. S. Scott, of the Westinghouse Co., gave a complete wiring diagram, with safety devices, for an electric jappanning oven, together with its motor-driven exhaustor. A japan which does not require a volatile solvent for thinning would represent an important step forward.

Mr. H. M. Lane emphasized the variety of conditions and problems met with in core-oven practice.

Mr. Richardson said that native China lacquer has no volatile solvent. It is always applied on muggy days, never on sunny days.

Mr. C. P. Madsen agreed with Mr. Lidbury that the commercial end of the electric heating industry contains very undesirable features, but he protested vigorously against Mr. Lidbury's complete condemnation of the electric heating art. It would be wrong for those who have electric heating problems to solve for their own use to try and solve their own problems. There are several electric companies whose industrial departments can give any desired information on electric heating, and there are independent "heating engineers" who give expert advice and solve heating problems for their clients. For many applications non-patented and comparatively inexpensive resistor materials are available.

The interesting, illuminating and in part very amusing discussion between Mr. Lidbury and Mr. Madsen was continued the next day; finally both found themselves in complete agreement.

In his final reply Professor Hirshfeld emphasized that the cost of energy is by no means necessarily the vital point. Ten years ago jappanning was done by coal and coke firing. The change to gas heating involved an energy differential of 18 to 1, but the higher cost of the gas was considered of minor importance. Why not now change to electric heating where the differential is so many times smaller than in the former case?

Switchboard for Experimental Furnace Work

The last paper of the Friday session was presented by Dr. W. L. Badger of the Chemical Engineering Department of the University of Michigan, describing an inexpensive and solidly constructed switchboard for laboratory use, especially arranged to give great flexibility of current in the operation of small electric furnaces.

Automobile Storage Batteries

The first paper of the Saturday session was presented by W. C. Brooks of the National Carbon Company, giving a very useful and instructive summary of the present status of the lead storage battery for automobile service.

The chemistry of the lead accumulator was reviewed; the service required in automobiles was classified as for ignition, starting and lighting, and motive power. The construction and design of each kind was discussed, also their electrical characteristics, followed by description of the causes of trouble and failure, with hints as to remedies.

Charging the Edison Storage Battery

A paper by Dr. M. De Kay Thompson and L. R. Byrne of the Massachusetts Institute of Technology on "the current efficiency in charging the Edison storage battery" reaches the following conclusions:

1. That an Edison battery, after standing for a long while requires a long charge to get it into good condition, and that the battery can be restored by this treatment.

2. At room temperature the efficiency of charging the iron plate is in general greater than that for the nickel plate.

3. At low temperature the efficiency of charging is reduced.

4. On starting the charging a maximum in the efficiency for both plates is reached in the early part of the charge.

Magnetite Electrodes

A paper by Dr. M. De Kay Thompson and T. C. Atchison was then presented, dealing with the production and properties of magnetite electrodes. It is published in full on page 605 of this issue.

Electrolytic Tungsten

The paper by W. E. Koerner of the Edison Lamp Works of the General Electric Co., at Harrison, N. J., on "The electrolytic behavior of tungsten," has already been published in our issue of Jan. 1, 1917, page 40.

The paper elicited quite an extended discussion as to the proper sign for electrode potentials and the proper use of the terms "higher" and "lower" potentials. Messrs. Frary, Fink, Watts, Hering, Mott, and Lidbury participated in the discussion. The outcome was that a motion of Mr. Mott was carried that a committee be appointed to look into the matter of nomenclature and report at the next general meeting.

Electrolytic Pickling of Steel

A paper on this subject, by Dr. M. De Kay Thompson and O. L. Mahlman of the Massachusetts Institute of Technology, was then presented.

All the iron or steel objects which in the process of manufacture have been heated in the air are covered with "fire scale," which is an oxide of iron corresponding in composition approximately to the formula Fe_3O_4 . This has to be removed before the surface can be plated or galvanized, and this is usually accomplished by immersing in some acid until the scale is removed by the hydrogen formed by the action of the acid on the iron beneath the scale, which it reaches through the cracks in the scale.

The action which would be expected if a sheet of iron covered with scale were used as cathode in an acid solution is a reduction of the higher oxide to lower oxide. This oxide would be dissolved by the acid. There would also probably be a certain amount of chemical action

between the iron under the scale and the acid, as in the purely chemical treatment. It is this action which the electrochemical process attempts to avoid as much as possible.

The electrolytic method has been patented by C. J. Reed, U. S. Patent, Nos. 855,667, 827,179, 827,180 (1907). See also *Tr. Am. Electroch. Soc.* 11, 181, 1907, and *Hering, Met. and Chem. Eng.* 13, 785, (1915). His specifications, which are followed in this investigation, are: Sulphuric acid of 1.2 specific gravity, at 60 deg. C., current density of 40 to 60 amperes per square foot (4.27 to 6.42 amperes per square decimeter). The anode is lead. The iron sulphate formed is to be removed from the solution from time to time by cooling to 0 deg. C.

The method of comparing the two operations consisted in treating two similar mild steel plates covered with equal amounts of scale by the two methods until their appearance showed the pickling was completed. The pickling baths were then concentrated until all solid matter which had dropped off was dissolved, and were then analyzed for iron. The amounts of iron dissolved in the two processes formed the basis of comparison.

The chief results of the investigation of the authors are as follows:

1. The relative efficiency of electrochemical and chemical pickling was determined, and the saving in expense which would be effected under the conditions of these experiments, showing greatly in favor of the electrochemical method.

2. The extent to which fused magnetite is reduced in sulphuric acid solution under different conditions of temperature and current density was also measured, and the best conditions of temperature and current density were determined.

In the discussion Dr. Hering stated that the chief advantages of the electrolytic pickling process are the saving of good iron and good acid. A large experimental plant is being erected to try out the process on a commercial scale.

Electroplating Papers

Dr. F. C. Mathers of Indiana University then presented four papers by himself and co-workers on different electroplating problems.

A paper by Dr. F. C. Mathers and K. S. Means describes "tests of antimony plating baths" in which the deposition of antimony from numerous electrolytes was tried, such as the tartrate, chloride, oxalate and fluoride, with the addition of glue, peptone, aloin, etc., as addition agents. The most satisfactory bath is the fluoride, containing free hydrofluoric acid and a small amount of aloin, resorcinol, alpha-naphthol, betanaphthol, or salicylic acid.

A paper by Dr. F. C. Mathers, K. S. Means and B. F. Richard discusses the "electrodeposition of antimony from fluoride baths containing addition agents." The deposition of antimony was studied from fluoride baths containing free hydrofluoric acid, with the addition of various kinds of organic addition agents. Without additions the deposit is crystalline, while very small amounts of various addition agents make it smooth and glossy. Aloin and clove oil are found most effective additions; the correct very small quantity must be maintained in the bath. The current efficiency is close to 100 per cent.

A paper by Dr. F. C. Mathers and T. G. Blue dealt with "addition agents in the electrodeposition of silver from uncommon silver salts."

Silver perchlorate, fluosilicate, fluoride and ethylsulphate baths were electrolyzed with glue, peptone, gum arabic and various other addition agents. The deposits

were somewhat better than with the same addition agents in nitrate baths.

Phenolsulphonic acid, cresolsulphonic acid, and their sodium or ammonium salts, sodium naphthalenesulphonate and sodium benzene sulphonate, 3 per cent in each case, when added to the silver baths, including the nitrate, restrained the formation of crystals in the same way as tartaric acid, but less effectively.

The use of unusual salts of silver does not seem to offer possibilities of obtaining much better deposits than from the nitrate.

A paper by Dr. F. C. Mathers and A. B. Leible discussed "essential oils as addition agents in plating baths."

Squares of sheet metal were shaken with aqueous solution of the oils, and the amount adsorbed determined by difference by titrating the residual solutions. The metals adsorb oil in decreasing order as follows: Lead, antimony, copper, cadmium, zinc, iron, tin, silver. This is approximately the order of increasing difficulty of preventing rough crystalline deposits by the use of the addition agents, and therefore proves in a general way the relation between the effect of the oils as addition agents and their adsorption by the metals.

A paper by Dr. Oliver P. Watts and Albert Brann of the University of Wisconsin discussed "the evolution of hydrogen from cyanide plating solutions."

Experiments were made with silver and copper cyanide solutions, with the addition of varying amounts of free potassium cyanide, to determine the effect of the latter in producing liberation of hydrogen at the cathode. The effect is much greater with copper solutions than with silver solutions. Test experiments show that the liberation of hydrogen is direct, and not due to action of the free cyanide, but to raising of the single potential necessary to deposit the metal until it reaches that sufficient to electrolytically set free hydrogen.

Electric Endosmosis

In a paper on "electrical endosmose and adsorption," by Drs. T. R. Briggs, H. L. Pierson and H. S. Bennett of Cornell University the relations are discussed between electrical endosmose and the adsorption theory of contact electrification. It is shown that this theory provides a rational explanation of the phenomena. The data accumulated by Perrin are found to be confirmed by the authors' experiments. The effect of temperature on the phenomena is studied in detail. Finally, the phenomena met in dyeing are discussed from the standpoint of the adsorption theory, and found to be in accord with the details of the theory.

Photochemical Cell

The last paper of the meeting dealt with "a cuprous oxide photochemical cell," the author being Theodore W. Case of Auburn, N. Y.

A large number of electrolytes were found which deposit by immersion upon copper a light-active coating, probably due to the formation of a copper oxide or halide salt upon the electrode. A copper formate electrolyte, containing free formic acid, using highly polished copper electrodes was studied closely. If one plate be illuminated and the other kept dark a current is produced, the illuminated plate being anode, and developing an E. M. F. up to 0.11 volt. The current finally drops to zero; but if the cell is rotated, illuminating the previously dark plate, the E. M. F. reappears. On continued rotation, the E. M. F. reaches a maximum value. Below a critical light intensity the cell gives very little response. The theory of the reaction is discussed.

After a very hearty vote of thanks to all who made

this meeting so successful, the meeting adjourned. The autumn meeting will be held from Oct. 3 to 6 in Pittsburgh.

The following is a complete alphabetical list of those who registered at the Detroit meeting:

G. L. Alber, Detroit, Mich.; W. H. Allen, Detroit, Mich.; R. J. Anderson, Cleveland, Ohio; J. C. Armstrong, Detroit, Mich.; F. C. Atwood, Thorold, Ont., Canada; W. L. Bauger, Ann Arbor, Mich.; R. O. Bailey, Onondaga, N. Y.; T. F. Baley, Altoona, Pa.; E. E. Bacon, Cleveland, Ohio; F. E. Bartell, Ann Arbor, Mich.; S. L. Bear, Pittsburgh, Pa.; M. H. Bennett, Waterbury, Conn.; E. B. Beggart, Toronto, Canada; C. E. Boyd, Detroit, Mich.; W. C. Brooks, Lakewood, Ohio; J. F. Burgess, Madison, Wis.; Prof. D. Campbell, Ann Arbor, Mich.; Miss Maude C. Carabin, Detroit, Mich.; S. C. Carrier, Brooklyn, N. Y.; R. T. Chace, R. M. Cemerhill, Detroit, Mich.; Mr. and Mrs. N. K. Chaney, Cleveland, Ohio; G. C. Clark, Detroit, Mich.; A. B. Conner, Detroit, Mich.; A. D. Cowperthwaite, Detroit, Mich.; Harold N. Cox, Woodhaven, N. Y.; F. Crabtree, Pittsburgh, Pa.; S. Crocker, Detroit, Mich.; Mr. and Mrs. E. L. Crosby, Detroit, Mich.; T. E. Crossman, New York City; R. A. Cuder, Cleveland, Ohio; C. Dantsien, Schenectady, N. Y.; J. M. Darke, Lynn, Mass.; A. C. Davis, Cincinnati, Ohio; C. N. Dawe, Detroit, Mich.; J. A. Dennison, Mich.; H. DeWitt, Detroit, Mich.; J. L. Dixon, Detroit, Mich.; G. H. Doan, Detroit, Mich.; J. V. N. Dorr, New York City; Mr. Dowd, Ann Arbor, Mich.; A. C. Downes, Fostoria, Ohio; A. J. Duke, Detroit, Mich.; Mr. and Mrs. E. G. Dygert, Detroit, Mich.; A. I. Ferguson, Ann Arbor, Mich.; C. G. Fink, East Orange, N. J.; Mr. and Mrs. F. A. Fitzgerald, Niagara Falls, N. Y.; R. F. Flinterman, Detroit, Mich.; F. C. Frary, Niagara Falls, N. Y.; G. P. Fuller, Niagara Falls, N. Y.; S. J. Fuller, Schenectady, N. Y.; R. H. Gaines, New York City; A. E. Gibbs, Philadelphia, Pa.; C. B. Gibson, Pittsburgh, Pa.; A. E. McK. Gilford, Pittsfield, Mass.; H. W. Gilett, Ithaca, N. Y.; G. Gilmartin, Detroit, Mich.; J. B. Glaze, Niagara Falls, N. Y.; S. L. Goodale, Pittsburgh, Pa.; Mr. and Mrs. H. Goodwin, Frémont, Ont., Canada; Miss M. Graham, Detroit, Mich.; J. Guinther, Welland, Ont., Canada; H. J. Hammond, Detroit, Mich.; Carl Herling, Philadelphia, Pa.; A. H. Hincley, Niagara Falls, N. Y.; Mr. and Mrs. C. P. Hirsfield, Detroit, Mich.; H. J. Hawkins, Detroit, Mich.; Mr. and Mrs. H. K. Hitchcock, Pittsburgh, Pa.; R. P. Hommel, South Bethlehem, Pa.; G. B. Hogaboom, New Britain, Conn.; C. W. Jinnette, Detroit, Mich.; J. Kelleher, Welland, Ont., Canada; Mr. and Mrs. H. W. Kellers, Niagara Falls, N. Y.; L. H. Knapp, Schenectady, N. Y.; B. R. Koering, Detroit, Mich.; J. Kreusi, Detroit, Mich.; A. H. Krieger, New York City; C. F. Kurtz, Bethlehem, Pa.; E. F. Lake, Detroit, Mich.; Mr. and Mrs. H. M. Lane, Detroit, Mich.; T. A. Leach, Chicago, Ill.; P. A. Libary, Niagara Falls, N. Y.; R. B. Lincoln, Detroit, Mich.; C. F. Lindsay, Ottawa, Canada; E. R. Little, Detroit, Mich.; W. B. Little, Detroit, Mich.; J. M. Lohr, Ithaca, N. Y.; G. E. Long, Napoleon, Ohio; H. E. Lowe, Detroit, Mich.; T. J. Mackay, Vanagh, Ann Arbor, Mich.; D. Maclean, Detroit, Mich.; J. R. MacMillan, Niagara Falls, N. Y.; R. J. Macy, New York City; C. P. Madsen, Newark, N. J.; S. R. Manning, Detroit, Mich.; A. L. Marsh, Detroit, Mich.; O. J. Marsh, Detroit, Mich.; F. Mathers, Bloomington, Ind.; D. L. Mathias, Pittsburgh, Pa.; L. R. McCleary, Buffalo, N. Y.; E. A. McDonnell, Detroit, Mich.; A. G. Melcher, Detroit, Mich.; A. A. Meyer, Detroit, Mich.; F. M. Meyers, Montreal, Canada; H. D. Miles, Buffalo, N. Y.; D. R. Miller, Niagara Falls, N. Y.; Mr. and Mrs. W. R. Mott, Cleveland, Ohio; Miss Ruth Mott, Cleveland, Ohio; J. M. Muir, New York City; J. C. Munn, Chicago, Ill.; Mrs. D. E. Murray, Detroit, Mich.; F. H. Nickle, Saginaw, Mich.; E. E. Niswonger, Dayton, Ohio; Mr. and Mrs. J. D. Noyes, Detroit, Mich.; J. W. O'Dean, Detroit, Mich.; S. S. Orth, Detroit, Mich.; A. B. Parfet, Detroit, Mich.; Miss F. I. Phipps, Detroit, Mich.; I. L. Pond, Detroit, Mich.; T. P. Purman, Detroit, Mich.; W. P. Putnam, Detroit, Mich.; C. F. Quaintance, Golden, Col.; A. G. Randall, Omaha, Neb.; G. K. Reel, Detroit, Mich.; G. Reeve, Greenwood, N. Y.; J. B. Reynaud, Detroit, Mich.; W. Richards, South Bethlehem, Pa.; H. K. Richardson, Waterbury, Conn.; Mr. and Mrs. E. G. Rippel, Buffalo, N. Y.; Miss Martha Rippel, Buffalo, N. Y.; E. F. Roebert, New York City; C. F. Roth, New York City; H. E. Rottmeyer, Buffalo, Pa.; W. E. Fuder, Schenectady, N. Y.; Mr. and Mrs. E. A. Rykenbon, Ann Arbor, Mich.; H. M. St. John, Chicago, Ill.; G. K. Saurwein, Detroit, Mich.; E. W. Seaholm, Detroit, Mich.; C. G. Schneiderberg, Pittsburgh, Pa.; J. D. Schueler, Peoria, Ill.; W. S. Scott, E. Pittsburgh, Pa.; J. A. Seede, Schenectady, N. Y.; E. M. Shepard, Jr., Detroit, Mich.; A. C. Shepherd, Cleveland, Ohio; Acheson Smith, Niagara Falls, N. Y.; B. Smith, Detroit, Mich.; H. H. Smith, Orange, N. J.; J. H. Smith, Milwaukee, Wis.; M. B. Smith, Buffalo, N. Y.; G. Reeve, Snyder, Pittsburgh, Pa.; S. Souder, Detroit, Mich.; F. N. Speller, Pittsburgh, Pa.; R. S. Sperry, Waterbury, Conn.; E. C. Stone, Hartford, Conn.; J. Sullivan, Detroit, Mich.; S. Temple, St. Paul, Minn.; Allan C. Thayer, Detroit, Mich.; F. H. White, Niagara Falls, N. Y.; O. F. Toward, Ohio; R. Turnbull, Welland, Ont., Canada; A. L. Twitcheell, Mansfield, Ohio; M. Unger, Pittsfield, Mass.; C. H. Vom Baur, New York City; F. Von Schlegel, Chicago, Ill.; L. Vorce, New York City; O. F. Watts, Madison, Wis.; H. E. Weller, Westport, Mich.; G. W. Wain, Narragansett Pier, R. I.; E. P. West, Detroit, Mich.; S. Westberg, Christiania, Norway; A. E. Wetmore, Detroit, Mich.; H. E. White, Buffalo, N. Y.; R. H. White, Niagara Falls, N. Y.; B. I. Whiting, New York City; B. W. White, Pittsburgh, Pa.; H. H. Ward, Ann Arbor, Mich.; E. G. Williams, Worcester, Mass.; A. M. Williamson, Niagara Falls, N. Y.; C. A. Winder, Niagara Falls, N. Y.; T. P. Wipperman, Detroit, Mich.; J. G. Wood, Indianapolis, Ind.

Analysis of Rutile

By E. W. Hagmaier

DETERMINATION OF SILICON

Fuse one-half gram of the finely powdered sample of rutile with as small amount of potassium bisulphate as possible. The fusion should be started at the lowest possible temperature, with the crucible covered,

and continued thus for about one hour; after which time the crucible or dish should be held in tongs and given a swirling motion and the temperature increased until complete fusion occurs. When cooling the melt turn the crucible slowly about in the tongs in order to have the melt solidify in a thin layer about the sides of the crucible. By handling the melt in this way it is very easy to remove the solidified melt from the crucible when it has cooled.

Transfer the fusion to a 250-c.c. beaker and have about 150 c.c. of 10 per cent sulphuric acid present; heat, but do not boil, and stir from time to time to accelerate solution. Do not heat too high or too long, for titanic acid will separate out and necessitate starting over.

When solution is complete and no undecomposed ore shows, filter, washing with warm 10 per cent sulphuric acid. Ignite the paper and precipitate in a weighed crucible, when completely ignited weigh and then treat the precipitate with sulphuric acid and hydrofluoric acid to volatilize the silicon. Weigh the crucible and difference is SiO₂ in the sample.

Any residue which might be in the crucible after the silicon is driven off should be fused with bisulphate and added to the main filtrate.

TITANIC ACID

To the filtrate which should now contain all the titanium, iron, etc., in solution add about 10 grams of ammonium sulphate and digest warm, not hot, until a few drops of ammonium hydroxide added locally gives a white precipitate. A slight amount of sulphurous acid solution may be added here. Now warm the solution to about 90 deg. C. and add ammonium hydroxide with continual stirring until showing a precipitate is about to form, but not a permanent precipitate. The solution may become opalescent but must not show a permanent precipitate.

Now, and not before add 30 c.c. or 40 c.c. of a concentrated solution of ammonium acetate. This addition should immediately cause precipitation. Boil vigorously for twenty minutes and then allow the precipitate to settle, and then filter on a fast running paper, washing by decantation with dilute ammonium acetate solution. After several washings by decantation transfer the bulk of the precipitate to the paper and wash the precipitate until a test with barium chloride shows no sulphates. When washing is complete, ignite first at a low heat to burn off the paper, and then strongly on the blast. Weigh, and again ignite to be sure of constant weight. When weight is constant add potassium bisulphate to the crucible and make a fusion as in the beginning, leaching out fusion with sulphuric acid as before. When solution is complete add a large excess of tartaric acid and then add ammonium sulphide, digest until the iron sulphide precipitate coagulates, then filter and wash once or twice.

Redissolve the precipitate in dilute sulphuric acid, add more tartaric acid and again precipitate the iron sulphide, filter and wash several times. Now dissolve the precipitate in hydrochloric acid and oxidize with a few drops of nitric acid, when oxidation is complete precipitate the iron with ammonium hydroxide, filter wash, ignite, weigh in the original crucible and deduct this weight of precipitate from the previous weight to get TiO₂.

OXIDE OF IRON

The iron is determined on a separate sample and is done as just described for iron as an impurity, after removing SiO₂.

Buffalo, N. Y.

Porcelain*

By A. V. Bleining

Porcelain consists essentially of clay substance in the form of kaolin or of a plastic white burning clay, and quartz cemented together by means of fused feldspar. Since kaolin and quartz are refractory materials, the feldspar functions as an igneous cement and unites the particles to form a dense, translucent mass. Varying as regards the proportion of these three constituents and in certain cases with the introduction of other materials, the typical porcelains of the world are produced. Since the softening temperature of feldspar corresponds to a temperature of about 1250 deg. C. (cone 8), it is evident that a high content of this mineral permits the use of lower firing temperatures than is possible with smaller amounts. It is obvious, on the other hand, that in no case can the firing temperature be much lower than the softening temperatures of the feldspar. In some products, as in the Danish porcelain, the firing temperature is carried very high, up to cone 18, or approximately 1500 deg. C. Again it is possible to lower the vitrification temperature of a porcelain by the introduction of accessory constituents, as in the English bone china, where calcium phosphate is used, or in the old French fritt porcelain in which a type of glass was employed to bring about vitrification. Small amounts of whiting, calcium carbonate, make up a part of many porcelains. This is explained by the fact that a mixture of about 96.5 per cent potash feldspar and 3.5 per cent calcium carbonate form a eutectic combination. With reference to the glaze still other differences may occur. Thus the hard fired porcelain of Continental Europe is first burned to a low temperature, about 980 deg. C., then glazed and refired to the maturing temperature of the body. The English bone china and a great deal of the American porcelain is burned first to the vitrification temperature of the mass, then glazed and refired to a comparatively low temperature, about 1050 deg. C. for the English china and 1180 deg. C. for the American table ware. The glazes which are used for this purpose are softer than the feldspar glazes of the so-called hard porcelain and consist of boro-silicates of potash, lead and lime. Within recent times there has been a distinct tendency on the part of the American manufacturers to raise the fusion temperature and with it the hardness of the glaze, so that it is not uncommon to find a porcelain fired to cone 10-11, and refired in the glaze burn to cone 8. In some cases also single fired porcelain is being produced in this country in which both body and glaze mature together at or just above cone 10 (about 1320 deg. C.).

The following types of porcelain may be distinguished:

1. American type porcelain.
2. Hard fire porcelain, Austria, Denmark, France, Germany, Japan and Sweden.
3. Soft porcelain, early French, Japanese and Seger porcelain.
4. Bone china.
5. Parian porcelain.
6. Refractory and special porcelains.

1. AMERICAN TYPE PORCELAIN

Although we cannot speak of a single type of domestic porcelain, the fact remains that the first firing of the body to its maturing temperature and its second

burning to a lower glazing temperature sets it aside from the European hard fire porcelain. However, different compositions are used for different purposes. Thus, the American table and sanitary ware body differs to some extent from that used in the manufacture of electrical porcelain and again from the porcelain produced in making white, vitreous floor tile. The latter corresponds more closely to the Parian porcelain. For the sake of illustration, the composition of the first two kinds of porcelains are given:

	(a) Table Ware, Per Cent	(b) Electrical Porcelain, Per Cent
Kaolin and ball clay.....	43	50
Feldspar	20	30
Quartz (flint)	36	20
Whiting, calcium carbonate.....	1	..

The lower temperature of biscuit firing necessarily produces a structure quite different from that obtained in porcelain burned to higher temperatures, as will be shown later. An American boro-silicate glaze cannot be compounded from the raw constituents owing to the solubility of the boric acid or its sodium salt and it is necessary to fuse this ingredient with part of the feldspar, flint, kaolin and whiting to form an insoluble glass. This is called fritt.

The composition of such a glaze maturing at about cone 3 will be as follows:

Fritt		Glaze	
	Parts by Weight		Parts
Feldspar	17.3	Fritt	195.4
Borax	104.2	Feldspar	23.4
Whiting	69.6	White lead	65.4
Kaolin	61.9	Kaolin	12.4
Flint	112.9	Flint	39.9

The desirable features of this type of glaze are the brilliant surface and its long heat range, making it possible to obtain bright glazes throughout the range of the commercial kilns.

For technical work, especially for once-fired ware carried to about cone 10 or higher, a hard porcelain glaze of the type:

	Parts		Parts
Feldspar	83.6	Flint	54.0
Whiting	35.0	Kaolin	25.9

is quite suitable, especially as it may be softened somewhat by the partial replacement of the whiting by zinc oxide and other bases. In the case of brown colored glazes used on insulators, ferric oxide is very active in lowering the fusion temperature of the glaze.

2. HARD FIRE PORCELAIN

As has already been stated, this type of porcelain is first fired to a low temperature, about 980 deg. C., and when glazed fired to temperatures between 1380 deg. and 1500 deg. C. A composition of this kind would be represented by the following mixture:

	Per Cent
Kaolin and plastic white clay.....	54
Feldspar	20
Quartz (flint)	24.5
Whiting	1.5

As a rule the content of clay substance is higher in these porcelains than in the American product. It is also necessary to employ in place of the so-called ball clays which are used in American and English bodies somewhat more refractory materials. This is necessary, owing to the high firing temperatures at which the dense burning ball clays would tend to "overburn," i.e., to show a tendency toward a vesicular or spongy structure. This point has been overlooked in several

*A paper presented at the Feb. 9, 1917, meeting of the New York Section of the American Electrochemical Society in joint session with the New York Sections of the American Chemical Society and the Society of Chemical Industry. Published by permission of the Director, Bureau of Standards.

instances in this country where it was attempted to produce hard fire porcelain and yet retain the use of the usual ball clays. It is evident that in the manufacture of such porcelain in this country more extensive use must be made of our plastic kaolins from Georgia and Florida. The European hard porcelains usually contain a small amount of biscuit body as a non-plastic.

The glazes of the high fire porcelains, maturing at the high temperatures in question, are exceedingly hard. They are not in the nature of the case as brilliant as our plumbiferous boro-silicate glazes and their color tends more toward a bluish white. This must be ascribed in part to the effect of the reducing conditions which are caused to prevail in the kilns. The firing is so conducted that reduction is most intense at the lower temperatures and is gradually diminished as the heat approaches the maturing point of the glaze. Hard fire glazes of this type correspond to the following mixtures, glaze "B" being of a more refractory character and requiring about cone 15 for complete fusion:

A		B	
	Parts		Parts
Feldspar	166.8	Feldspar	166.8
Whiting	70.0	Whiting	55.0
Kaolin	51.6	Kaolin	77.4
Flint	168.0	Magnesite	12.6
		Flint	276.0

Chemical porcelain does not differ essentially from the average type of hard porcelain, as may be seen from the following analyses of German chemical ware:

	Royal Berlin Chemical Porcelain, Per Cent	Royal Berlin Porcelain, Per Cent	Thuring- ian Chemical Porcelain, Per Cent	German Chemical Porcelain, No Mark, Per Cent
Silica	68.27	67.91	67.31	73.44
Alumina	26.63	26.89	25.83	21.77
Ferric oxide	.89	.78	1.11	.73
Titanium oxide	.26	.44	.32	.19
Lime	.69	.44	1.20	.19
Magnesia	.86	.41	.47	.08
Soda	.39	.46	.71	.38
Potash	1.92	2.78	2.51	3.61
Loss on ignition	.06	.15	.80	.05

Montgomery in his work on chemical porcelain, on the other hand, reports that the best results are obtained with compositions of high clay content.

3. SOFT PORCELAIN

The typical Japanese and the early French fritt porcelains are examples of this type of body. The former consists of 40 per cent clay substance, 36 per cent feldspar and 24 per cent quartz. Usually the feldspar is entirely introduced as pegmatite with its accompanying share of quartz. Of late the Japanese are producing porcelain approaching closely the European hard porcelain. The French fritt porcelain, in which a glass or fritt is used as the fluxing constituent, is no longer being produced and is only of historic interest. The present French porcelain products approach very closely the average hard fire porcelains of Europe. A decorative soft porcelain developed in Germany is the so-called Seger porcelain consisting of 25 per cent clay substance, 45 per cent quartz and 30 per cent feldspar. It is biscuit fired at cone 10, and matures with the glaze at cone 8-10. The glaze consists of 166.8 parts feldspar, 70 whiting, 51.6 kaolin and 108 flint. It is used only for art ware.

4. BONE CHINA

Bone china is the typical vitreous product of England, characterized by its beautiful texture and adaptability to rich decoration. It is composed of 40-50 per cent of bone ash (calcined bone), 20-30 per cent Cornish stone

and 25-30 per cent of clay substance. The biscuit burn is carried to cone 8-10, while the glaze is fused on at quite a low temperature, about 1050 deg. C. The ware requires considerable skill in the several stages of manufacture, and hence makes necessary a staff of well-trained workmen.

5. PARIAN PORCELAIN

This body is intended principally for the production of unglazed statuary and figures, and in the United States it is employed in the manufacture of impervious white floor tiles. It is composed of 50 per cent of feldspar, 40 per cent clay substance and 10 per cent ground quartz. Its burning temperature is carried to cones 8-9. In appearance it has an agreeable matt texture without the glassy sheen of the usual porcelain body.

6. REFRACTORY AND SPECIAL PORCELAINS

The best known type of refractory porcelain is the Marquardt body, in which sufficient alumina is added to the kaolin to approach the composition of sillimanite. The minimum amount of feldspar possible is employed to bring about a sufficient degree of vitrification. Bodies of this type are used in the manufacture of pyrometer tubes and similar articles. The manufacture of the Marquardt porcelain was introduced in the United States by the Bureau of Standards. The tubes are made by pressing them through dies or by the casting process.

As in the manufacture of European hard fire porcelain, the biscuit firing is carried only to a low temperature and the glaze is applied on the porous body. The glost fire is carried to cone 16-18. The body of the American Marquardt porcelain is composed of the following materials:

	Body Mixture, Per Cent	Calcine No. 1, Per Cent	Calcine No. 2, Per Cent
Calcine No. 1	45.7	..	..
Calcine No. 2	7.3	..	..
North Carolina kaolin	17.0	22	..
Florida kaolin	5.0	..	..
Delaware kaolin	10.0	..	..
Ball clay	15.0	..	..
Feldspar	8	64	..
Calcined alumina	..	70	36

The calcined mixtures should be brought to a temperature corresponding to that of cone 18, approximately.

The glaze may be either matt or bright. The former is somewhat more desirable, since it does not "stick" as easily as the latter, which is more of a glassy nature. The two glazes are made up of the following constituents:

	Matt Glaze, Parts by Weight	Bright Glaze, Parts
Kaolin (raw)	60	119
Kaolin (calcined)	152	100
Whiting	100	65
Feldspar	..	83.7
Magnesite	..	16.8
Ground quartz (flint)	108	426.0

The field of special porcelains is a most interesting one and promises the production of types possessing certain specific properties which may be useful with reference to special uses such as spark plugs, electrical porcelain used under abnormal conditions, etc. Thus, we have to consider the complete or partial replacement of feldspar by calcium and magnesium silicates, and of quartz by the use of such constituents as fused alumina, zirconium oxide, titanium oxide and other constituents.

Effect of Firing Porcelain

In the molding and shaping of porcelain in nearly every case a certain characteristic structure is developed which is retained to a greater or less extent in

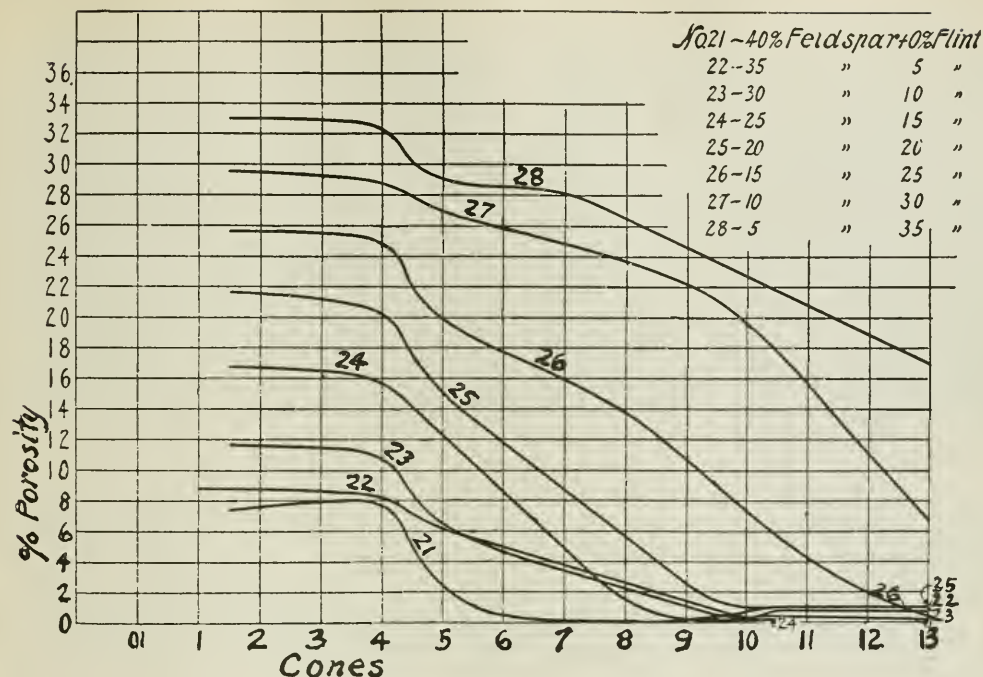


FIG. 1—DIAGRAM SHOWING EFFECT OF DIFFERENT PERCENTAGES OF FELDSPAR ON VITRIFICATION OF PORCELAIN

the finished ware. Thus in shaping an electrical insulator on the wheel the density of the body close to the surface is greater than that within the piece due to the fact that the pressure of the tool is not uniformly distributed throughout the mass. Similarly, when forced through a die, lamination is produced owing to the greater velocity of flow in the interior than at the exterior of the column. The rate of flow of the water from the interior to the surface and its rate of evaporation is likewise of some importance, inasmuch as strains may be developed either by too rapid or unequal drying. It is essential that the porcelain be thoroughly dried before being placed in the kiln. A small amount of hygroscopic water still remains to be driven off. At 500 deg. C. and above the chemical water of the kaolin is driven off, a change indicated also by the expansion of the porcelain. After the dehydration stage the body reaches its most porous condition. This is followed at about 900 deg. C. by an exothermic reaction accompanied by condensation of the structure. The exact nature of this change first observed by Le Chatelier is not known. By some it has been attributed to polymerization, by others to the formation of sillimanite. This stage is followed by increasing condensation to be ascribed in part to colloidal contraction and later to an increasing extent to the softening of the feldspar and other fluxes. The effect of the feldspar is observed even at temperatures as low as 1150 deg. C. In fact, it has been found that extremely fine ground feldspar may cause the porcelain to become dense at 1170 deg. C. In this case the amount of feldspar present must be quite large. The vitrifying effect of feldspar approaches its maximum as its softening temperature is exceeded. At the same time the density of the feldspar is lowered, and with it that of the body, so that the temperature-specific gravity relation is a fair index of the progress

of vitrification. This process may be considered as being due to the effect of surface tension which, owing to the decreased viscosity of the mass, is capable of contracting it, thus filling the pore space and tending to produce rounded outlines, comparable to the formation of a drop of water.

The effect of increasing amounts of feldspar upon the vitrification process measured by the drop in porosity is shown in the diagram of Fig. 1. It will be observed from this data that with 40 per cent of feldspar complete vitrification is reached at cone 7, a point which is displaced toward higher temperatures as the feldspar is diminished and the quartz (flint) is increased. With 15 per cent feldspar and 25 per cent quartz, vitrification is not reached before cone 13. Using a pure kaolin as clay substance, as in this case, 10 per cent of feldspar did not suffice to bring about a vitrified structure at the temperature corresponding to cone 13.

Diagrams showing the relation between the porosity, contraction (expressed in per cent of the original volume) and temperature are exceedingly useful in the study of the proper vitrification temperature and the point of overfiring which results in the formation of a vesicular, spongy structure. At the same time, the general slope of the curve is indicative of the rate of vitrification. Such a diagram representing a typical hard porcelain is shown in Fig. 2. It will be noted that complete vitrification as measured by the non-absorption of water by the body (in vacuum) has taken place at 1313 deg. C., and that overfiring occurs at about 1430 deg. C. The curve showing the volume changes is especially valuable in readily detecting important changes. Data such as these should be determined for every porcelain body, since they might prevent serious manufacturing losses. The porosities of such a series of specimens of a porcelain are readily determined upon

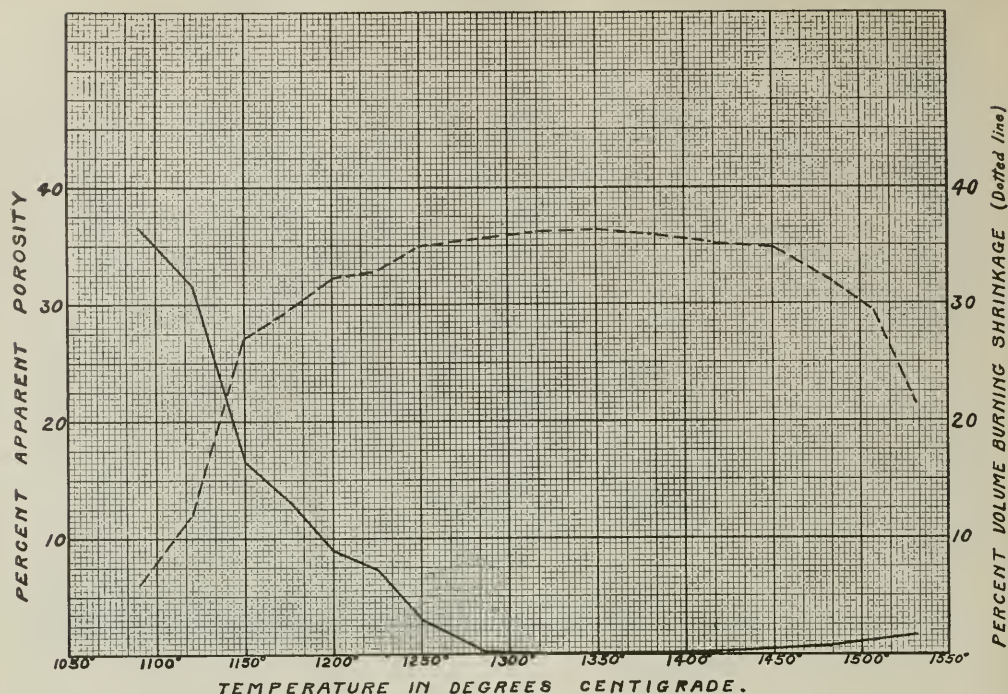


FIG. 2—DIAGRAM SHOWING POROSITY AND VOLUME CHANGES WHEN FIRED TO DIFFERENT TEMPERATURES

pieces drawn from the kiln at the different temperatures. The same pieces may be used also for measuring the volume changes by means of a voluminometer.

The function of the quartz in porcelain is first that of a non-plastic, reducing the drying shrinkage and preventing warping. In the firing process it forms the skeleton of the body, increasing its rigidity and preventing deformation. As the fusion of the feldspar progresses, solution of the quartz takes place, the finest particles being, of course, dissolved first. This solution is first noticeable at about 1325 deg. C. Porcelains which are not fired to temperatures above 1350 deg. C. hence show but little solution. This is illustrated in the microphotograph of Fig. 3, representing a section of American porcelain in which it is observed that all of the quartz grains retain their sharp edges with no appreciable evidence of solution. At about 1375 deg. C. solution of the quartz becomes quite marked and at 1425 deg. and above practically no quartz grains remain. It is interesting to note that no evidence of the transformation of quartz to cristobalite or tridymite is observed. It is suggested by Klein that the solution of the quartz by the feldspar proceeds faster than its transformation to the other crystalline forms.*

In heating the porcelain during the first stage of the firing the transformation of alpha to beta quartz takes place at 575 deg. C. and on cooling the reverse change occurs. This transformation has been held responsible for stresses set up in the porcelain and for the phenomenon of "dunting," the property of heavy porcelain pieces of fracturing, occasionally with explosive violence, after taking them from the kiln. It has been thought that the use of ground quartz is more apt to cause dunting than amorphous silica, which would be introduced in using French flint. On the other hand,

the use of very fine ground quartz, though in a smaller proportion than commonly employed, has been advocated as a solution of the difficulty. Previously calcined quartz also is said to give better results than the raw ground material.

The clay substance of the porcelain when the higher temperatures are reached gives distinct evidence of dissociation resulting in sillimanite and free silica. At first the former is present in the amorphous state, but later there is distinct evidence of crystalline sillimanite and its needles may constitute a large proportion of the porcelain mass. In the microphotograph of Fig. 4, a section of Japanese porcelain is shown in which this crystallization is very evident. At the same time, it is interesting to note the evidence of quartz solution. The smallest grains have already become part of the glassy matrix, while the larger grains have become rounded. Evidence of the dissociation of kaolin is observed at about 1225 deg. C., at 1300 deg. it is practically complete and a small amount of crystalline sillimanite appears. At 1400 deg. the clay substance is completely dissociated to form crystalline sillimanite. Hard porcelain, therefore, consists of glassy material to which it owes its translucency, crystalline sillimanite and some undissolved quartz. At 1425 deg. C. comparatively little quartz remains as such.

In the American type of porcelain, on the other hand, very little sillimanite appears, the quartz is dissolved only to a slight extent and for this reason the amount of glass formed is very much less than in the high fired porcelain.

Defects of Porcelain

Faults occurring in porcelain may consist in the so-called crazing and shivering, dunting, insufficient union of body and glaze, warping, vesicular structure, dull-

*Technologic paper No. 80, Bureau of Standards.

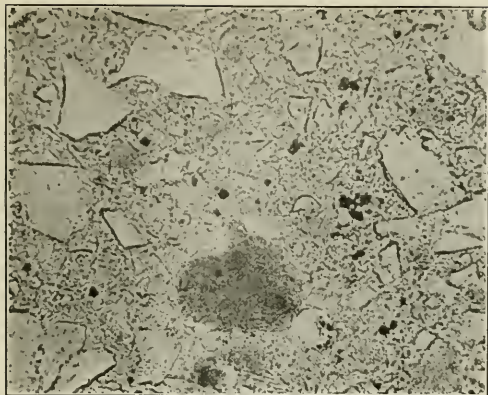


FIG. 3—MICRO-SECTION OF AN AMERICAN PORCELAIN
(BY KLEIN)



FIG. 4—MICRO-SECTION (BY KLEIN) SHOWING STRUCTURE
OF JAPANESE PORCELAIN

ness and roughness of glazed surface, and poor color. Crazing is caused by the greater coefficient of thermal expansion of the glaze, and at the same time by an imperfect union between it and the body. Shivering has been assumed to be due to the reverse cause, but the difficulty seems to be accentuated by other causes as well, such as too high a content of quartz, or quartz ground too coarsely. Dunting seems to be intimately connected with the volume changes of the quartz, though it is quite possible that other factors may be involved as well. Even under the best possible conditions the surface of the porcelain is certain to be under considerable stress. Rupture under abnormal conditions such as extremely rapid heating and cooling is avoided only where there is a well-defined region of interaction of body and glaze, shown by the growth of sillimanite crystals with the glaze, a condition illustrated in the microphotograph of Fig. 5. Such a complete union is especially necessary for chemical porcelain and many failures of this kind of ware can be traced to the absence of this intimate surface interaction. The remedy in a case like this is invariably firing to a higher temperature and such changes in the composition of the body which will enable it to stand up under the higher heat intensity.

Warping may be due to either defective support of the ware in firing or to faulty composition which brings about a state of too low viscosity at the temperature employed. The content of feldspar and other fluxes such as lime must be kept as low as possible, and should just suffice to bring about vitrification. Considerable skill is required in designing shapes least subject to deformation in firing and also in the use of proper supports, rings, etc. The formation of a vesicular structure may be induced by firing to an excessively high temperature, by firing too long or by faulty composition of the body. Sometimes ball clays or other plastic clays are used which cannot be carried to porcelain kiln temperatures. Such cases have been observed occasionally and could be traced to the use of plastic ball clays which cannot produce a sound body under the kiln conditions prevailing in the firing of hard porcelain. Dullness of the glaze surface and the appearance of bare spots may be due to a variety of conditions. Faulty application of the glaze, its absorption by the body when the firing is continued too long or is carried too high, the effect of sulphur gases in the kiln, a too heavily reducing kiln atmosphere, the presence of sulphates in the body, and other factors may be responsible for the difficulty. A

color bordering on cream may be ascribed to a high iron content in the body or improper firing, usually in the failure to maintain reducing kiln conditions during the early part of the burning. Very slow cooling may also be responsible for it. The practice of producing the bluish white color of hard fire porcelain by this method of firing cannot be employed in the case of porcelains covered with a glaze containing lead oxide for obvious reasons. It is for this reason that our vitreous table ware has a creamish cast. A very fine white European porcelain was found to contain 0.34 per cent Fe_2O_3 and 0.1 per cent TiO_2 .

Physical Properties of Porcelain

SPECIFIC GRAVITY

The specific gravity of the average porcelain may vary from 2.24 to 2.35. It decreases as complete vitrification is reached and shows a further decrease as this point is exceeded and the state of viscous fusion is approached.

MECHANICAL STRENGTH

The compressive strength of porcelain varies from 50,000 to 65,000 lb. per square inch. The tensile



FIG. 5—MICRO-SECTION SHOWING JUNCTION OF BODY AND
GLAZE, WITH SILLIMANITE CRYSTALS GROWING
INTO GLAZED GERMAN PORCELAIN

strength is given as being about 13,000 lb. per square inch, and the modulus of elasticity as about 7,000,000.

THERMAL PROPERTIES

The coefficient of expansion varies for different porcelains and with temperature. For atmospheric temperatures it fluctuates between 0.0000025 and 0.0000045. The mean coefficient of expansion of Berlin porcelain has been found to be 0.00000343 between 23 and 200 deg. C., and 0.00000356 between 23 and 700 deg. C. Porcelain fired at higher temperatures possesses a lower expansion value than a lower fired product. Purdy and Potts found low temperature porcelain to show the lowest coefficient of expansion when the quartz-feldspar contents approached the ratio 1:1. The mean specific heat of porcelain was found to be 0.202 between 20 and 240 deg. and 0.221 between 20 and 400 deg. C.

The thermal conductivity likewise increases with temperature and up to 100 deg. C. it is approximately 0.0045 (calories per second per cubic centimeter and for 1 deg. C. temperature difference). Taking the conductivity of silver to be 100, that of porcelain would be approximately 0.04. Resistance to sudden heating and cooling is essential in the case of such ware as chemical porcelain. This quality is usually estimated in an arbitrary manner by heating the specimen to red heat or any convenient temperature and cooling it rapidly either in a current of cold air or by quenching in water. It would be a more systematic procedure to heat the pieces to a definite temperature in a suitable oven and to quench them suddenly in water, noting the number of treatments they can withstand. A temperature of 200 deg. C. would be suitable for this purpose, since it seems to be a sort of critical point. Another procedure would be to heat the specimen to a series of temperatures beginning with 150 deg. C., quenching them, and if failure has not taken place to raise the temperature 10 deg. and to repeat the procedure until a temperature is reached at which checking or cracking occurs. The maximum temperature thus reached would be indicative of the quality of the material. It is obvious that in all such tests the size and shape are important factors which render the determinations often of doubtful value. It is necessary that the specimens be of simple shape as plain crucibles and of the same size.

ELECTRICAL PROPERTIES

The electrical conductivity of porcelain is very low at atmospheric temperatures, showing a maximum resistance of 200×10^{10} megohms per centimeter. With increasing temperature the resistance decreases rapidly and, according to Haber, the porcelain becomes an electrolyte below 900 deg. C. At 727 deg. C. Berlin porcelain was found to show a resistance of 1.7×10^4 ohms per square centimeter, per centimeter. The following relation has been suggested:

$$\log R = a + \frac{b}{T}, \text{ where}$$

R = resistance, T = absolute temperature, a and b = constants. The dielectric constant for Hermersdorf porcelain was found to vary between 4.5 and 5.3. Plates of the same porcelain possessed a dielectric strength of 50,000 volts for a thickness of 5 mm. and 90,000 volts for 10 mm. This resistance drops rapidly with the temperature. Henderson and Weimer found that at 275 deg. C. the dielectric strength dropped to about one-thirtieth of the initial value.

MISCELLANEOUS PROPERTIES

The velocity of sound through good porcelain has been found to be about 5000 m. per second. Inferior

porcelain shows lower values. Since the pitch of the tone heard when porcelain is struck is a function of the sound velocity, a criterion is thus offered for estimating its quality.

Glazed hard fire porcelain is impermeable to gases up to about 1300 deg. C. Porcelain is more resistant to chemical agencies than glass, and even alkaline solutions attack the glaze but slightly. It is entirely resistant to acids. It is, of course, attacked quite rapidly by fusing alkalis and by phosphoric acid. At higher temperatures it permits also the slow penetration of metallic oxides, carbon, etc.

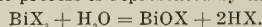
Bureau of Standards,
Pittsburgh, Pa.

The Equilibrium of the Basic Bismuth Salts A New Method of Determining the Concentration of the Hydroxyl Ion

By A. Mutscheller

The precipitation of a basic bismuth salt by an excess of water is a classic experiment on hydrolysis. The decomposition of bismuth chloride, bromide or nitrate by water is simple when compared with the hydrolytic decomposition of antimonium chloride. While the latter forms, according to concentration, different products, it was found by Herz and Bulla,¹ and it was later confirmed by René Dubrisay, that the halogen salts of bismuth form, at ordinary temperature, only basic salts of the type BiOCl or BiOBr .

These investigators have hydrolyzed bismuth chloride and bromide at various concentrations and have invariably found that the sediment had the composition BiOCl or BiOBr respectively. They concluded, therefore, that the hydrolytic process is represented by the formula,



The same investigators also performed a series of experiments for the purpose of determining the nature of the equilibrium of the basic bismuth salts. Since the reaction, for instance, for the chloride is $\text{BiCl}_3 + \text{H}_2\text{O} = \text{BiOCl} + 2\text{HCl}$, the equilibrium of the same is, according to the law of mass action, fixed by

$$\frac{[\text{BiCl}_3][\text{H}_2\text{O}]}{[\text{BiOCl}][\text{HCl}]^2} = k;$$

but since BiOCl is present in the solid phase and H_2O is in excess, the expression reduces itself to $\frac{[\text{BiCl}_3]}{[\text{HCl}]^2} = k$.

When they hydrolyzed 1 gr. of bismuth chloride in various volumes of water or in solutions of hydrochloric acid of different strengths they found that the ratios between the concentrations of the bismuth and the square of the concentration of the hydrogen ion found in the equilibrium mixture gave, for the BiCl_3 at 25 deg. C., the constant 0.025. For the bromide they found it to be 0.051.

The reports of the above investigators, therefore, indicate that if we add water to a solution containing the normal Bi^{+++} ion, a precipitate is formed consisting of the basic bismuth salt of the type BiOX . There is also an equilibrium maintained between the concentrations of the bismuth and the hydrogen ion in the solution that gives an equilibrium constant according to the law of mass action.

Reports of several chemical analyses on the percentage composition of the precipitate, however, reveal it to be a mixture of the monovalent hydrate and its anhydrid ($\text{Bi}(\text{OH})_X$ and BiOX) in proportions depending on the temperature of dehydration or drying of the

¹Zcit. f. *Anorgan. Chemie*, vol. 61, p. 387 (1909); *Comptes Rendus*, vol. 40, p. 530 (1909).

precipitate before the analysis. It is reported that the water-free product was only obtained by heating to 110 deg. C. and cooling over concentrated sulphuric acid to constant weight. If we, on this evidence, assume that the precipitate originally had the composition corresponding to the complex monovalent bismuth hydroxide ion $\text{Bi}(\text{OH})_2^+$, there is analytical proof that this state of hydration is unstable and that water is readily given off from it. This peculiarity, therefore, characterizes the tendency of the trivalent Bi^{+++} ion to pass over into the form of the hydroxyl or oxygen-containing monovalent $\text{Bi}(\text{OH})_2^+$ or BiO^+ cation, which form is clearly shown with the oxalates, chromates or organic acid compounds of bismuth.

We find in the literature and in general textbooks the statement that bismuth hydroxide is insoluble in alkalis. However, it was shown by L. Moser² that bismuth hydroxide shows solubility with stronger (over normal) solutions of the caustic alkalis.

Furthermore, it is a well-known fact that many salts depress the hydrolytic decomposition of bismuth chloride. Herz and Bulla,³ through carefully conducted experiments, showed that the chlorides of sodium, potassium and ammonium, or any of the remaining alkali chlorides, influence the hydrolysis of bismuth chloride in the same direction and to the same extent. They found that the concentration of the bismuth ion becomes greater in proportion with the increase of concentration of the chloride ion. Their results further show that the presence of nitrates or sulphates hardly influences the hydrolysis of the bismuth chloride.

L. Moser⁴ describes two modifications of bismuth hydroxide which correspond to the formulae $\text{Bi}(\text{OH})_2$ and BiOOH . The second forms from the first under the influence of light or heat and, at lower temperatures, in the presence of strong alkalis. He arrives at the conclusion that even freshly prepared $\text{Bi}(\text{OH})_2$ is insoluble in solutions of caustic alkalis up to normal strength, but that the presence of caustic alkalis in higher concentrations produces the transition of the normal hydroxide into the orthohydroxide BiOOH .

The solubility of bismuth hydroxide in stronger caustic alkali solutions seems, therefore, to consist in the passing, perhaps irreversibly, of the fresh normal $\text{Bi}(\text{OH})_2$ into the second modification; but as the previously dried salts do not seem to show this solubility it appears as if the equilibrium is approached from the other side with very slow velocity.

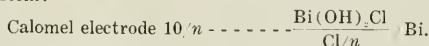
These observations are, therefore, unmistakable indications that the basic bismuth chloride maintains constant equilibrium ratios between the bismuth and the hydrogen ion concentration either in the presence of chlorides or of the hydroxide alkalis, according to the law of mass action.

PRELIMINARY CONSIDERATIONS

The topic of this investigation forms part of a problem now under investigation, and has for its object the study of the relationship which exists when the basic bismuth salts are in contact with certain acids or the caustic alkalis. The results which are herein presented are sufficient for the purpose, but to make this investigation a complete and exhaustive study on the equilibrium it is necessary to go further and determine the solubility or solubility product of the basic salts either in presence of an acid or one of the caustic alkalis. The electrolytic solution pressure of bismuth should also be determined. The method adopted is the one which suggests itself from the observations men-

tion in the introduction, namely, to determine by potential difference measurement the relation between the potential difference and the concentration of the bismuth ion in contact with metallic bismuth.

Arranging the various substances so as to conform to the type of a concentration chain gives the following system:



The potential difference of this chain evidently depends on the bismuth ion concentration which results from the dissociation of the dissolved part of the basic salt which is in equilibrium with the other ions present, for the right-hand half electrode is evidently an electrode of the second kind or a reversible electrode.

The potential difference of this chain consists of the differences:

- (a) At the contact of mercury with the solution;
- (b) At the contact of the two solutions, and
- (c) At the contact of bismuth with the solution.

Leaving out of consideration the potential at the contact of the two solutions, the potential difference between the two electrodes is, according to Nernst, represented by the formula:

$$E = E_1 - E_0 = \frac{0.05771}{n_c} \log \frac{P}{p} \text{ volts at 18 deg. C.}$$

E_1 is the potential of the 1/10 normal calomel electrode, P is the electrolytic solution tension of bismuth, p is the osmotic pressure of the bismuth ions in the solution, and n_c , so long as monovalent ions are in questions, is equal to 1.

EXPERIMENTAL PART

Materials.—Solid bars of metallic bismuth which were purchased as "c. p." were carefully cleaned with sand paper and suspended in a solution of dilute nitric acid. This treatment gave them a slightly roughened surface with a uniform homogeneous appearance. The first few series of experiments were made with these electrodes, but it was later found that if dipped after this treatment into strong nitric acid and immediately afterward into water, they became coated with a deposit of the basic salt. After careful washing they showed then greater consistency and came to an equilibrium in a shorter time.

The basic salts were prepared by dissolving the basic carbonate (bismuth subcarbonate) in a just sufficient amount of either strong nitric or hydrochloric acid. When the solution was clear, it was heated to drive off carbon dioxide, and was then poured into a large volume of cold distilled water. The precipitate was then washed for twenty-four hours. After that time no appreciable acidity or alkalinity could be detected when the washings were tested with litmus or phenolphthalein.

The standard Weston cell and the 10/ n calomel electrode employed for the above measurements had been used successfully in other work. The bridge wire used for the estimation of the potential difference was a Kohlrausch bridge wire made by Leeds and Northrup. The standard acids and alkalis were carefully prepared and standardized. The temperature was kept constant in a thermostat and was maintained in the neighborhood of 18 deg. C.

Mixtures.—The solutions which were successively brought in contact with the metallic bismuth were prepared by first washing the precipitated basic salt with water, as indicated, for twenty-four hours. The water was then decanted and the precipitate covered with standard acid or alkali solution. After stirring and a short time of standing, the solution was renewed four or five times. Testing the potential after each washing

²Zeit. f. Anorgan. Chem. c, vol. 61, p. 379 (1909).

³Loc. cit.

⁴Loc. cit.

showed that it remained absolutely constant after the second or third washing. The electrode was then introduced, the connections were made with the calomel electrode, and the difference of potential was measured.

RESULTS

The various concentrations of acids or alkalis that were kept in contact with the various basic salts of bismuth, and the potential differences observed under these conditions, are given in the first two columns of Tables

TABLE 1

Bi(OH) ₃ Cl + NaOH series.		NaOH Added		Moles		Volts		Log ϕ		3 Log c.		Log $\phi + 3 \text{ Log [H]} =$	
No.	per Liter											Const.	
2	0.000					+0.486		8.42		0.0000		1.58	
3	0.001277					+0.451		8.14		1.32-10		1.68	
4	0.00255					+0.358		6.20		2.22-10		1.58	
5	0.0051					+0.299		5.18		3.12-10		1.70	
6	0.01275					+0.224		3.89		4.32-10		1.79	
7	0.10					+0.070		1.21		7.00-10		1.79	
8	1.00					+0.0907		1.57		0.00		1.57	
11	0.050					+0.134		2.32		6.09-10		1.59	

Table showing the relation between the concentrations of the NaOH added and the potential differences observed.

TABLE 2

Bi(OH) ₃ Cl + HCl series.		NaOH Added		Moles		Volts		Log ϕ		3 Log c.		Log $\phi + 3 \text{ Log [H]} =$	
No.	per Liter											Const.	
1	0.001275					+0.515		8.93		7.10-10		6.03	
9	0.10					+0.415		7.20		9.00-10		6.20	
10	1.00					+0.360		6.23		0.00		6.23	

Table showing the relation between the concentrations of the HCl added and the potential differences observed.

TABLE 3

Bi(OH) ₃ NO ₃ + NaOH series.		NaOH Added		Moles		Volts		Log ϕ		3 Log c.		Log $\phi + 3 \text{ Log [H]} =$	
No.	per Liter											Const.	
2	0.000					+0.492		8.53		0.000		1.47	
3	0.001275					+0.453		7.85		1.32-10		1.17	
4	0.00255					+0.354		6.13		2.22-10		1.66	
5	0.0051					+0.302		5.23		3.12-10		1.65	
6	0.01275					+0.230		3.99		4.32-10		1.70	
7	0.10					+0.074		1.28		7.00-10		1.72	
8	1.00					+0.091		1.57		0.00		1.57	

Table showing the relation between the concentrations of the NaOH added and the potential differences observed.

TABLE 4

Bi(OH) ₃ NO ₃ + HCl series.		NaOH Added		Moles		Volts		Log ϕ		3 Log c.		Log $\phi + 3 \text{ Log [H]} =$	
No.	per Liter											Const.	
1	0.001275					+0.510		8.84		7.10-10		5.74	
9	0.10					+0.394		6.82		9.00-10		5.82	
10	1.00					+0.347		6.03		0.00		6.03	

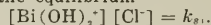
Table showing the relation between the concentrations of the HCl added and the potential differences observed.

Table 5. Bi(OH)₃NO₃ + H₂SO₄ series.
0.050 + 0.523 volts (inconstant).

1 to 4. The plot of the relation between the concentration and the difference of potential shows the interesting fact that the changes of potential due to the addition of an alkali are greater than for the corresponding addition of acid. It also shows that the sulphates or nitrates produce different changes of potential when in contact with the basic bismuth chloride from the chloride ion in similar contact. On the other hand, the presence of sodium hydroxide with either the basic nitrate or the chloride of bismuth gives practically identical potential differences.

These experiments and the work of the above named observers tend to show that, in the acid solution making contact with the basic salt, it is the anion that is influencing the equilibrium, since different anions have different influences on it. In the alkaline solution, however, one and the same hydroxide has the same effect

on different basic salts of bismuth. The rearrangement of the equilibrium when other ions are being added must, naturally, take place according to the law of mass action, this leading us to assume that, in the acid solution, we have the equilibrium

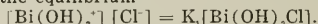


For the alkaline solution we should have, according to this view,

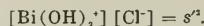


To show that these assumptions are correct the following analysis on the results is made.

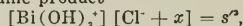
The mixtures that formed contact with the metallic bismuth electrode, consisted of a solution of the basic salt, with the presence of a known concentration of an acid or of sodium hydroxide. If we consider, for example, the case of the basic bismuth chloride, there is, in solution, the equilibrium



The solubility product, according to this equation, is expressed by



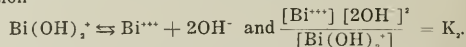
The presence of x moles of chloride ion in the solution causes the concentrations of the ions to rearrange, making the same product



for if we add x moles of chloride ion, the concentration of the total chloride ion will be increased; since, however, the solubility or ionic product cannot be exceeded, the concentration of the bismuth ions in the solution must decrease. Assuming that it decreases to $[\text{Bi}(\text{OH})_3]$, and the total chloride ion concentration increases to $[\text{Cl}^- + x]$, their product is given by the above expression.

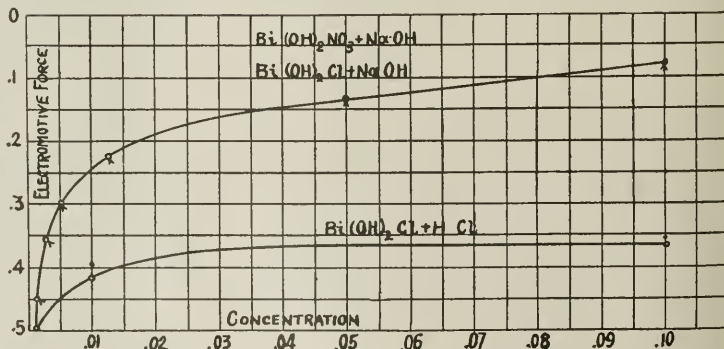
According to this we have the concentration of the bismuth hydroxide ion given by $[\text{Bi}(\text{OH})_3] = \frac{s^2}{[\text{Cl}^- + x]}$. The concentration of Cl^- , on account of being very small, is generally neglected. Hence $[\text{Bi}(\text{OH})_3] = \frac{s^2}{[x]}$ is the final concentration of the bismuth hydroxide ion in presence of x moles of chloride ion.

This ion, however, is undergoing secondary ionization



Substituting, therefore, the above relation in this equation we obtain $\frac{[\text{Bi}^{+++}] [2\text{OH}^-]^2 \cdot [x]}{s^2} = K_2$, or

$$[\text{Bi}^{+++}] = K_0 \frac{s^2}{[x]} \dots \dots \dots (1)$$



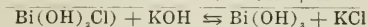
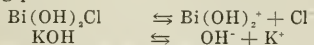
CURVE SHOWING THE RELATION BETWEEN THE POTENTIAL DIFFERENCES OBSERVED AND THE IONIC CONCENTRATIONS

if we neglect the already small and finally disappearing $[2OH^-]^2$. This expression then represents the concentration of the bismuth ion in a solution which is in contact with washed basic bismuth chloride and a solution containing x moles of hydrochloride acid.

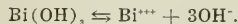
In the presence of an alkali the relation makes a somewhat different appearance. If we again start with the well-washed basic chloride, we have, in solution, the equilibrium



When KOH is added to this solution, the following reaction is taking place



The bismuth hydroxide formed in the solution ionizes according to



Due to the very small solubility of the bismuth hydroxide, we have again the solubility product

$$[Bi^{+++}][3OH^-]^3 = s''^4$$

The addition of x moles of hydroxide ion causes a rearrangement of the equilibrium to

$$[Bi^{+++}][3OH^- + x]^3 = s''^4$$

If we then again neglect the very small concentration of $[3OH^-]^3$, we obtain, as the final concentration of the bismuth ion in the solution containing x mole of

$$\text{hydroxide ion as } [Bi^{+++}] = K_{so} \frac{s''^4}{[x]^3} \dots \dots \dots (2)$$

Making contact between this alkaline or the acid solution in the presence of the basic bismuth chloride and a metallic bismuth electrode, and connecting this system with a similar vessel giving a known difference of potential, we obtain a cell of which the difference of potential depends on the concentration of the bismuth ion in the solutions which make contact with the metallic bismuth electrode.

If we introduce these ionic concentrations in the equation giving the potential difference of a concentration chain, we obtain, for the acid solution,

$$E = 0.613 - E_o = 0.05771 \log \frac{P \cdot [x]}{s'^2}$$

For the alkaline solution we obtain from (2)

$$E = 0.613 - E_o = 0.05771 \log \frac{P \cdot [x]^3}{s''^4}$$

These two equations should, if the above reasoning is correct, give the relation between the potential differences of the cells, arranged as outlined, and the concentrations of the ions, either the chloride or the hydroxide ions that were added to the basic salt.

In order to bring these equations into a better form it is necessary to make the following transformations:

$$\text{If } E_o = C \log \frac{P \cdot [x]}{s'^2} \text{ then } \frac{E_o}{C} = \log [x] + \log \frac{s'^2}{P}$$

In the present case, both the electrolytic solution tension of bismuth and the solubility product of the basic salt are unknown. In general agreement, however, with the evidence which we have on the subject, we can assume that neither the solubility product of the basic salt nor the electrolytic solution tension of bismuth are changing when the concentration of the chloride or the hydroxide ion is changing. The constancy of the value of these two factors could, therefore, be taken as an indication that the potential difference and the concentrations are varying according to the ratio fixed by the given equations.

$$\frac{E}{C}$$

$$\text{If we now put } \varphi = \frac{E}{C}, \text{ we obtain } \log \varphi = \log [x] + \log \frac{s'^2}{P}$$

Using Briggs logarithms φ becomes equal to 10 and

$$\text{hence } \log \varphi = \frac{E}{C}$$

This makes the two equations in question appear as

$$\log \varphi = \log [x] + \text{const.}, \text{ for the acid solution, or as}$$

$$\log \varphi = 3 \log [\varphi] + \text{const. for the alkaline solution.}$$

The two constants are, of course, not equal, for we are dealing with solubility products of different salts.

This test was applied to the results obtained given in Tables 1 to 4. Constant values are in column 6.

The tables show that the constants, obtained by the addition of identical hydroxide ion concentrations either to the basic chloride or the basic nitrate of bismuth, are almost equal. This indicates that the solubilities of the basic nitrate and the basic chloride are (in so far as the accuracies with which they are expressed in the equations are concerned) nearly equal. But it also brings out the fact, that in both cases it is the hydroxide ion which causes the rearrangement of the equilibrium; as in the present case, for instance, with two basic bismuth salts having different anions but having cations both of which, on further ionization, yield the same concentrations of hydroxide ions.

Tables 2 and 4 show that there are considerable differences between the constants when we add equal concentrations of hydrochloric acid to the basic chloride and the basic nitrate respectively. The effect of the chloride ion on the equilibrium is, therefore, different with the two salts; and this difference must be taken as an indication that the chloride ions which exert an influence on the equilibrium are the common ion, which then causes the decrease in the concentration of the bismuth ion in order to make the solubility product of the salt in solution again equal to its original value.

SUMMARY

The conclusions that can be derived, at present, are that in acid solution the basic bismuth salts ionize into a complex monovalent bismuth hydroxide ion $Bi(OH)_2^+$ and a monovalent anion maintaining a constant equilibrium ratio. In the presence of an alkali hydroxide the basic salt ionizes into the trivalent bismuth ion Bi^{+++} and three monovalent hydroxide ions $3OH^-$. In this case also, there is maintenance of an equilibrium in accordance with the law of mass action.

DETERMINING CONCENTRATION OF THE HYDROXIDE ION

In view of the satisfactory agreement of the results, and the constancy and accuracy with which the concentration of the hydroxide ion concentration can be calculated from the potential difference measurements, the cell consisting of the basic chloride or nitrate and an electrode of metallic bismuth is suggested as being very serviceable for the rapid and accurate determination of the concentration of the hydroxide ion, either in clear inorganic solutions or in solutions containing colloids or organic substances such as proteins, etc.

It has been shown that reversible electrodes or electrodes of the second kind are suitable for the determination of the ratios of distribution of ions between a solvent and adsorbing colloids. Electrodes of the first kind are not always applicable, for the contact of gases with the mixtures produces, in many cases, precipitation of one of the constituents. This, of course, causes always a disturbing derangement of the equilibrium.

In its present form, the method is to some extent empirical, for the constants found hold only for the temperature of 18 deg. C. The accurate determination of the electrolytic solution tension of bismuth and of the solubility of the various basic salts is in progress. If these factors are definitely known the method may be considered fully developed and not to depend on em-

pirically calculated constants. It is hoped that a further report on these determinations can soon be made.

Biochemical Laboratory, Columbia University, New York City.

An Enlarged Electron of Practical Size: The Faraday

By Carl Hering

It is the fashion to-day to talk in terms of electrons, the entities which compose the atoms. Physicists tell us that the smallest atoms are about one-three-hundred-millionth of an inch in diameter, and the largest not many times this; that there would have to be a row of about 200 of them to form something large enough to be visible in the most powerful microscope known; that if a drop of water were enlarged to the size of the earth, the atoms in it would be about the size of a baseball; that helium gas contains 77 billion-billion atoms per cubic inch, presumably meaning at atmospheric pressure. And still further straining our abilities of conception, they tell us that the negative electrons, which are supposed to be all alike, are about a one-hundred-thousandth part of an atom; that if an average atom were enlarged to a sphere 100 yards in diameter, the electron would be about the size of a pin-head, though its density is said to be a million-million times that of the atom.*

Such staggering and bewildering figures, and the fact that they are not yet accurately known, make it impossible to talk quantitatively about electrons in practice, yet if the engineer is supposed to deal with electrons he must know something more precise about the quantity of negative electricity which an electron represents.

The chemist who has had to deal with these tiny atoms in a quantitative way, has solved this difficulty in practice by the ingenious and perfectly satisfactory and accurate method of imagining a practical substantial form of atom, or "life-size" atom, to consist of a certain number of millions of the real atoms; the exact number is not known nor is it necessary to know it, as long as all of them have been increased exactly the same number of times. If the atomic weight of hydrogen is 1, then this aggregation or enlarged, practical atom is by definition such that it weighs 1 gram, and when the atoms of all the other elements are increased in number the *same number of times* the practical atoms will weigh as many grams as are represented of their atomic weights; these enlarged, practical atoms are the well known gram-atoms of the chemist, the gram-molecules being similarly defined. These practical atoms are quite substantial and workable amounts, being easily weighed and measured. Thus a gram-atom of copper weighs 63.57 grams, a piece of copper about the size of a large marble, and a gram-molecule of hydrogen under normal conditions measures 22.39 liters, or a little less than a cubic foot.

This ingenious and quite satisfactory scheme of the chemist to get over this difficulty naturally suggests that a similar method might be used to establish a substantial, workable, "life-size" electron. Fortunately a simple relation exists which makes this quite practical.

It is known from Faraday's law that an atom of every element requires exactly the same quantity of electricity to oxidize or reduce it electrochemically per unit change of valence, hence the gain or loss of the same number of electrons, whatever that number is. For the chemist's enlarged, practical gram-atom, it is known definitely that this quantity is equal to 96,494 coulombs or 26.80 ampere-hours, which is also a sub-

stantial, easily measured quantity, and like the gram-atom requires no straining of the imagination to conceive it; it is in fact a very large amount for a gram-atom to carry when we conceive that it means a charge which could cause a steady flow of nearly 27 amperes for one hour. This constant quantity has received the name of a faraday and is now beginning to be referred to in literature by that name.

It will be seen therefore that if the constant (the unknown) quantity of electricity which is gained or lost when one real atom is oxidized or reduced electrochemically, be multiplied by the same (unknown) number that the real atoms have been multiplied by to make the practical gram-atoms, it will be equal to the faraday. Hence this definite quantity of electricity (the faraday) is obtained quantitatively in exactly the same way from the minute, unknown quantities of electricity, as the definite quantity of matter (the gram-atom) is obtained from the minute, unknown quantity of matter in a real atom, thus deducing a real, definite, substantial quantity from the realm of the unknown and inconceivable. Even another unknown quantity is eliminated thereby, namely the number of real electrons which a real atom gains or loses in being oxidized or reduced; this need not be known either in establishing these substantial, workable units in this way.

The faraday may therefore quite consistently and correctly be called a *gram-atom-electron*, or enlarged electron, or popularly, a life-size electron, and with this understanding this enlarged electron can be rationally and correctly used in calculations and in literature; and as its size is so inconceivably larger than the real electron, no confusion could ever arise in the intelligent mind as to whether the real or the enlarged electron is meant if the latter is referred to more briefly as an electron, just as the chemist may and often does refer briefly to the atom when he really means the enlarged gram-atom.

Thus it is quantitatively correct to say that a gram-atom of hydrogen (1.008 grams) loses one enlarged electron (one faraday or 26.8 ampere-hours) on being reduced, or that one gram-atom of iron (55.84 grams) gains three enlarged electrons (3 faradays or 80.4 ampere-hours) on being oxidized from iron to the ferric state. Each of the + and — signs often placed over the symbols of atoms showing the free charges carried after dissociation, and every unit of valence, therefore represents an enlarged electron of one faraday if the symbol represents a gram-atom. Similarly each bond then represents quantitatively the attraction of one negative faraday or enlarged electron on one element to one positive electron on the other.

Whether chemical reduction is a loss of negative electrons, as stated above, or a gain, is perhaps still controversial, and not yet proved physically; whichever it is, oxidation is the exact reverse; this does not affect what has been said above about the quantity of the enlarged electron, but merely the direction of its flow. At present the opinions are deduced from arguments involving the definition of what the real processes of reduction and oxidation mean; the writer considers that the true reduction occurs during the decomposition or dissociation of a compound, while some others consider it to occur when the element of an already decomposed or dissociated compound is finally set free. The writer cites the case of reducing the iron in ferric compounds to ferrous, which is a true reduction, yet no iron has been set free. This subject was discussed more fully in an article by the writer on "Oxidation and Reduction in Physical-Chemistry—Consistency of Terms and Conceptions," published in the May 1 issue of this journal, page 507.

*Comstock and Troland, "The Nature of Matter and Electricity."

The Grinding Wheel—A Link Between Electric Furnace and Automobile*

By Richard G. Williams

The words "abrasive wheel" are perhaps more indicative to an electrochemist and "emery wheel" to some automobile manufacturer than the words "grinding wheel." However, the manufacturer of grinding wheels is of the opinion that neither "abrasive wheel" nor "emery wheel" really fits the situation, and so prefers the words "grinding wheel." Emery is only used to a very slight extent at present, and since an ordinary barnyard sandstone is an abrasive wheel, it is hardly correct to use abrasive wheel either, because the modern grinding wheel is an efficient cutting tool and must not be confused with sandstones and emery wheels.

The success of the modern grinding wheel is dependent to a very large degree upon a product of the electric furnace, namely, artificial abrasives. Artificial abrasives are of two kinds, or two groups, the aluminous group and the carbide of silicon group. The first contains aluminium oxide as the main constituent, and the different materials vary quite widely in physical properties, according to their chemical composition and electric-furnace treatment; while the carbide of silicon abrasives, forming the second group, vary but slightly in chemical composition and physical properties. These groups of artificial abrasives vary in characteristics almost as much as the different alloy steels which have been developed in the electric furnace by the initiative and resource of electrochemists. No product of the electric furnace, however, has a larger field of importance, nor has more profoundly influenced modern mechanical production and methods, than artificial abrasives. In view of the fact that the automobile industry is probably the best example we have of rapid production and advanced modern methods, you can readily appreciate the importance of artificial abrasives in this industry, and a short description of the manufacture of abrasives will be in order.

Considering first the aluminous group, the raw material must necessarily be a substance high in aluminium oxide. The most satisfactory material is a high-grade bauxite, although satisfactory abrasives are being made from other materials, such as low-grade bauxite and emery. Aluminous abrasives are made in the arc type of furnace. These furnaces often consist of a wrought-iron shell or some form of pot lined with carbon. The electrodes are suspended in the pot and then lowered to the bottom of the furnace, a train of graphite or fine coke placed between the electrodes, the current turned on and an arc suitable for fusing is available as soon as the train of graphite or coke has volatilized.

Before fusion in the electric furnace the bauxite receives a calcining treatment to drive off 30 per cent of combined water. Suitable chemicals are mixed with the calcined ore in order to facilitate the removal of such materials as iron and silicon. Furnaces of three-ton capacity consume about 650 to 700 horsepower and it takes approximately 24 hours for a furnace run. After the run is completed the shell is stripped off or the furnace sides removed and the pigs allowed to cool. When the pigs have cooled to a sufficient temperature, they are broken up by sledge hammers into pieces convenient for putting through a large jaw crusher. This operation reduces the material to pieces about the size of a man's fist, and in this condition the abrasive is sent to the grinding-wheel factory for further treatment.

The carbide of silicon abrasives have been described

so many times that it hardly seems necessary to again mention their manufacture, particularly to the American Electrochemical Society. In order to have the subject complete, however, a few remarks will be given.

The resistance type of furnace is used. The heat radiated and conducted from a central core of finely ground coke is used for the formation of the abrasive. The raw materials are coke, sand, sawdust, and a little salt, the object being to extract the carbon from the coke, the silicon from the sand and tie these up in the ratio of 1 to 1. It takes about thirty-six hours for a furnace run and approximately 1000 hp. is consumed. After the furnace has cooled considerably the outside layer of semi-decomposed materials is stripped off, and carbide of silicon is found to exist in a comparatively thick shell around where the coke core originally existed. It is an easy matter to break this shell up into pieces convenient for handling. The material is then sent to the grinding-wheel factory.

PREPARATION OF THE ABRASIVE GRAIN

When the crude abrasive in lumps ranging in size from those that will pass through a 6-in. (15 cm.) ring and smaller are received at the grinding-wheel factory the first step in the production of grain to be used in grinding wheels and other products such as oilstones, rubbing bricks, refractories and so forth is to pass through powerful crushers, equipped with manganese steel jaws. This operation reduces the material to small lumps. It is further reduced from lumps to grains by passing through succeeding rolls, each set being somewhat smaller than that preceding. In this way a range of sizes from very coarse to very fine is produced.

Some abrasives as received in the grinding-wheel factory contain an appreciable proportion of material which is magnetic and which is detrimental to the manufacture of wheels. This material is, therefore, removed by means of a magnetic separator.

The next step is washing. The material is placed in suitable machines and by means of agitating devices in connection with a current of water, the very fine sizes and dirt or dust which the material may have picked up are thereby removed. After washing, the material is dried in a very simple type of dryer. This consists of boiler plate shell, on the inside of which are longitudinal vanes. The shell is tilted somewhat, revolves slowly and the material allowed to fall upon a series of steam coils which are located in a central position inside the shell.

The final operation is sizing. The material is fed in a uniform stream on top of horizontal screens which are mechanically agitated. The resulting average size of grain depends upon a number of factors, among which the following are mentioned: Amount of feed, speed of agitation, length of the strokes, size of the wire in the screen, and size of the aperture.

To produce very fine grains, which are referred to as flours, hydraulic classifiers are used. The basic principle is the same as in any type of hydraulic classification, namely, the material to be sized is introduced into water moving with a definite velocity. The velocity is sufficient to carry away the finer portion of the material, while the rest is heavy enough to remain in the original container. It might add interest to describe various pieces of apparatus, but as each piece is special and the product of careful experimentation, it would not be in order to go into detail in a general paper of this type.

MANUFACTURE OF GRINDING WHEELS

The term "grinding wheel" as here used is intended to apply to wheels made by bonding abrasive in a suitable manner and then subjecting the whole to heat treatment. This distinguishes a grinding wheel from

*A paper read at the Detroit meeting of the American Electrochemical Society, May 3, 1917.

a grindstone, which is nothing more or less than a piece of stone quarried out of the ground and worked to suitable dimensions. It is also necessary in order to be comprehensive and strictly up to date to narrow the consideration even further and omit all references to the natural abrasives such as emery and corundum. We are, therefore, in this paper dealing only with the artificial abrasives, except where it is necessary to mention the natural ones as a matter of comparison.

All grinding wheels are composed of two main constituents:

1. *The Abrasive.* This is in grain form, the sizes of the grain depending upon the use to which the wheel will be put.

2. *The Bond.* This is a name used to indicate the material or substance by means of which the particles of abrasive are held together. In other words, the bond serves as a setting for the abrasives, and in this manner the face of a grinding wheel presents a more or less constant distribution of cutting particles.

Vitrified Wheels: The commercial method of classifying grinding wheels is by the kind of bonding material used. The most important type of wheel is the vitrified. The bonding material in this type is composed of various kinds of clay mixed together according to definite, secret formulas. A weighed amount of the abrasive, a weighed amount of the bond and a measured amount of water are all placed together in a mixing kettle, the whole thoroughly stirred for a definite length of time to insure uniformity, and then the mixture is drawn off from the bottom of the kettle into molds and allowed to dry.

After the wheels have dried they are taken to a department known as the shaving department. Here the wheels are turned to the approximate dimensions and shape the order calls for.

Pressed Wheels: A certain variety of vitrified wheels is made by what is known as the pressed process. Here the bonding clays only have enough water added to them to make the particles stick together to a slight degree. The abrasive and bond are mixed in kneading machines, and after a uniform mixture is obtained, the mass is placed in an iron mold, uniformly distributed throughout the mold, and then the material is subjected to pressure by means of powerful hydraulic presses, the number of pounds per square inch being dependent upon the grade of hardness desired. After pressing, these vitrified wheels do not need shaving, but can be placed directly in the kilns for heat treatment.

Heat Treatment: The next operation in the manufacture of vitrified wheels is the heat treatment in the kilns. The object is to submit the abrasive and dry clay to a heat which will properly vitrify and mature the bond. The highest temperature reached is about the melting point of steel, and the length of time required for heating, the length of time held at high heat and the cooling period are very important.

The kilns are usually of the up and down draft, pottery variety, and are fired by a series of hard-coal fires placed equally around the base of the kiln. The most common type of kiln is the single stack, natural draft, although some are in use which lead to a central stack.

After the kiln has cooled sufficiently the wheels are taken out, or unloaded, as the men in the factory say.

Silicate Wheels: In this class of wheels, as the name indicates, the bonding material is a silicate. A commercial grade of silicate of soda, commonly known as water-glass, is the main constituent and to this are added certain chemicals to make the bond water-proof. A weighed amount of the grain and a measured amount of the bonding material are placed in long cylinders,

and these are slowly revolved end for end until a uniform mixture is obtained. The mixed mass is placed in an iron mold of the approximate dimensions the order calls for and rammed into place by means of hand hammers or air hammers. This is a rather delicate operation in that the personal equation enters to quite a large extent. After sufficient ramming, the wheel is placed, while still in the mold, in an oven heated by means of an ordinary coal fire. After the baking treatment the wheels are hard, and from here on they are treated the same as any other type.

Elastic Wheels: This name is derived from the fact that the bonding material has quite a degree of elasticity. The main constituent of the bond is of organic nature, the most satisfactory material being shellac. To this is added certain chemicals to facilitate hardening in the baking and also to make the wheel waterproof. A weighed amount of the grain and a weighed amount of the bond, containing shellac in flake form, are placed in mixing machines, similar to the ordinary power bread mixer, containing kneading paddles. After the mixing process the whole mass is dumped out into a large shallow pan and allowed to cool, in which condition it is brittle. This brittle cake of abrasive and bond is broken up into small pieces and then put through a series of rolls which break the mass up into the individual grain. The rolls do not fit close enough, however, to reduce the size of the grain, the idea simply being to produce a mass composed of loose grains, each of which has a coating of shellac. In this form the material is placed in an iron mold the approximate shape of the wheel, the mold and all are placed in a steam box and heated up to the temperature where the shellac is again of a workable consistency. In this condition the abrasive and bonding material is subjected to pressure in a heavy press, the number of pounds per square inch depending upon the degree of hardness desired. After this pressing operation the mold and all is again placed in another steam box and heated for a length of time which will permit the bond to become permanently hard. From here on this type of wheel is treated exactly the same as any other.

Vulcanized Wheels: Here again the name is indicative, the bonding material being rubber. The manufacture of vulcanized wheels is almost the same as that of any other hard-rubber product. A weighed amount of the very best grade of crude rubber, the right proportion of sulphur, and a weighed amount of grain are thoroughly mixed together by numerous passes through horizontal rolls so located that the material passes down in a vertical direction. After a uniform mixture is obtained, the mass is again passed through a set of rolls, this time so located that the material passes through in a horizontal direction. It is rolled down to the desired thickness, cut out to the desired diameter, and a hole of the desired diameter is also cut out in the center. The next operation is vulcanizing, and the vulcanizing of rubber wheels does not differ from the vulcanizing of any other rubber product. From here on, this type of wheel is also treated the same as any other.

Truing and Bushing: The next operation is that of truing, namely bringing the wheels to the true dimensions called for on the order. The wheels are mounted in a three-jaw chuck, revolved, and special tools resembling an emery wheel dresser brought up against the side of the wheel.

In order to bring the wheels to the desired diameter they are firmly held to a revolving arbor and the dressing tool passed back and forth across the face, gradually reducing the wheel to the desired size. For fine wheels which must be carefully shaped on the face,

a diamond is used. This is mounted securely in a fixture and the diamond slowly passed across the face of the wheel, light cuts only being taken, as otherwise there would be a tendency to crack and destroy the diamond.

In this department the bushing, as it is termed, is also placed in the wheel. This consists of lead, except where experience has shown that it is advisable to use a harder material, in which instances babbitt is used. The wheel is allowed to rest on its side in a three-jaw chuck, carefully centered, then a steel arbor from 0.002 to 0.005 in. (0.05 to 0.13 mm.) larger than the desired hole in the wheel, is placed in the center hole in the chuck and the lead then poured around the arbor. The lead solidifies in a few minutes, when the wheel is removed from the chuck, and the arbor is carefully driven out with a soft hammer. The bushing is then trimmed, so that it does not extend quite flush with the sides of the wheel. This is to provide clearance so that when the wheel is mounted on the machine there will be no possibility of the holding stresses being concentrated at the hole of the wheel.

Speed Test: The next operation in the manufacture of wheels is revolving at a speed higher than the wheel is recommended to operate, in order that the manufacturer may know that his product goes out with sufficient factor of safety. The testing speed for wheels is 9000 surface feet per minute (2700 m.) except those of organic bonds which are tested at a somewhat higher speed. Since wheels are recommended to operate in the neighborhood of 5000 surface feet per minute (1500 m.) this gives a factor of safety, based upon the square of the speed, of between three and four. A careful record of every test is kept, and before filing the men making these records are required to go before a justice of the peace and swear that their statements are true and correct. When a wheel has successfully passed the speed test and the records of the testers have been inspected, the manufacturer has gone as far as he can in assuring the trade that they are receiving a product which is safe to operate.

Final Inspection: The wheels next pass through a department where they receive final inspection. Here care is used to see that the right wheels are going to the right customer and that dimensions and other specifications called for by the order have been exactly complied with.

Packing and Shipping: The wheels are held rigidly in position in boxes or barrels by means of tightly rammed sawdust. Wheels go directly from here to the freight cars and are shipped to destination.

Grading: Grade is the word used to designate relative hardness of any given wheel. Different methods are in use of indicating grade, although the most common is to use the letters of the alphabet. One company uses the first letters of the alphabet for the harder grades, the middle letters for the medium grades and the last letters of the alphabet for the softer grades. Another company uses just the reverse of this method while others use a system based upon some particular word.

Grade is determined by measuring the resistance which a wheel offers to the penetration of a small steel tool resembling a screw driver. The wheels coming through the process are compared with wheels of known hardness so that all variable factors are reduced to a minimum.

Since one of the important steps in the manufacture of grinding wheels is a heat treatment, a quantity of wheels all heat treated at the same time will vary somewhat in hardness. This becomes evident by a consideration of the fact that the individual parts of

any lot of material which is heat treated, for example a lot of automobile gears, will vary somewhat after being hardened. It is therefore necessary to test after hardening, by means of a scleroscope or some other instrument, to be sure gears are not passed which are too hard or too soft. Those coming within a certain range of hardness can be used satisfactorily.

The belief is quite common that a grade is an exact value. This belief can probably be traced back to the wheel manufacturer endeavoring to educate his trade to the state of mind whereby it will be believed that competitors' wheels may vary in grade, but his will not.

A grade is not an exact value, it is a *range between limits*, and all wheels which come within this range are of one grade and carry the same grade letter.

A lot of wheels, all of the same dimensions, the size of grain, but different grades, were slowly speeded up to a point where centrifugal force became greater than the hardness of the wheel and breakage occurred. The number of pounds per square inch tensile strength to

which each wheel

was subjected at the time of breakage was calculated by using a formula.

The values given in Figs. 1 and 2 should not be taken as exact, because formulas for centrifugal force in grinding wheels vary somewhat, but the figures will do for the purpose of comparison.

Fig. 1 illustrates the popular conception of grinding wheel grade, namely, that it is a definite value. For instance, take grade L. Reading on the left-hand side of

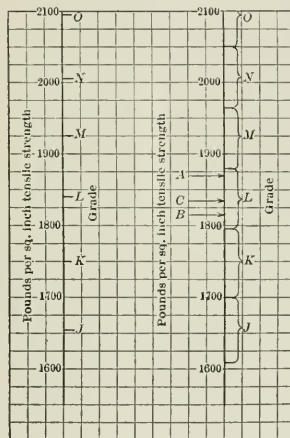


FIG. 1.

FIG. 2.

the line, we see that 1840 lb. per square inch tensile strength is directly opposite. The statement is often made that it is a physical impossibility for the wheel manufacturer to exactly duplicate grades, in that the wheels will come plus, that is slightly harder, or minus, slightly softer, than grade desired. Statements of this kind are based on the conception illustrated in Fig. 1.

Fig. 2 gives more nearly a true representation of the facts in the case. Here it will be seen that grade L embraces a range of value between limits, the limits as calculated being 1795 lb. per square inch (1.25 k. per sq. mm.) as the soft limit and 1880 lb. per square inch (1.32 k. per sq. mm.) as the hard limit. A wheel of a tensile strength between these limits is truly a grade L. Likewise all grades are a range between limits.

This explanation may possibly assist in understanding the reason why wheels of the same grade, for example, two grade L wheels, may vary quite noticeably in a grinding action. Consider one wheel almost soft enough to be grade K and another almost hard enough to be grade M, as shown by the arrows A and B in Fig. 2.

Assume a certain grinding operation is being performed, all the variable factors of which, such as speed of work, speed of wheel, depth of cut, kind of material, etc., combine to bring a pressure against the wheels rep-

resented by arrow *C*. The wheel represented by arrow *A* will have long life while the wheel represented by arrow *B*, not being strong enough to stand up under the pressure of the operation, wears away quite rapidly, in fact very much more rapidly than the difference in hardness would seem to indicate.

GRINDING CHARACTERISTICS OF VARIOUS ABRASIVES

Probably the most important physical property of an abrasive is hardness. Other properties such as toughness and ability to resist shock are also important, but knowledge of the art of grinding has not advanced sufficiently far so that we can definitely state the relative importance of the different physical characteristics; that is, we cannot state upon which of the properties the grinding action of the abrasive most depends. We know that the artificial abrasives are harder than corundum but not as hard as diamond. It is extremely difficult to determine differences in hardness of the artificial abrasives and for this reason we are sometimes led to believe that hardness is not so very important. This is because there is wide difference in the grinding action of existing abrasives and but little difference in hardness, as determined by present methods. However, if the hardness of mineralogical materials could be brought down to a satisfactory basis where variation could be measured in units of uniform size, we would probably find that there is as much variation between nine and ten on "Mohs" scale as there is between one and nine. Hardness has been determined with sufficient accuracy, however, to make it possible to give the following statement with confidence.

Carbide of silicon abrasives are harder than aluminous abrasives.

When a grinding wheel containing a certain abrasive, satisfactorily grinds very tough material, we say the particular abrasive is possessed of considerable toughness. Whether or not this is the right word to use this paper will not discuss. Until the experiments which are being continually conducted have proved otherwise, the trade will continue to refer to this characteristic of abrasives as toughness.

We can readily conceive of two different materials, one of which is possessed of the properties of hardness and brittleness, while another may be less hard and tough. The brittle material may have sufficient strength to stand up under relatively light pressure, while the other material possessing less hardness but being more tough, may wear away so rapidly, due to its lower hardness, that the desirable property of toughness becomes entirely secondary.

Under other conditions we might have pressure brought to bear against the brittle material which it could not withstand, thus causing excessive wear, while the tough material, even though of lesser hardness, nevertheless is hard enough to stand up under this pressure for a sufficient length of time to be considered satisfactory.

The theory outlined above is quite frequently used to explain the marked difference in grinding action between the aluminous and carbide of silicon abrasives. Actual experience has shown that when materials of low tensile strength such as cast iron, brass, bronze, etc., are ground, carbide of silicon, which is hard but relatively weak, is more efficient than the aluminous abrasives. On the other hand, when grinding materials of high tensile strength, ranging all the way from medium carbon to the high-speed steels, we find that aluminous abrasives give better satisfaction than carbide of silicon.

Research is continually being conducted to bridge the gap between the two abrasives. Success is already

accorded in the aluminous group. A material which is on the market and which carries the trade designation of 38 alundum, is better adapted for grinding certain kinds of steel than the original material which is known as regular alundum. This latter material, however, is better than the No. 38 material on certain classes of work. Other varieties of aluminous abrasives come somewhere near these two but enough difference exists to be a sales factor. There is still a big field for research, and the manufacturers of artificial abrasives are very active and there is every promise of new varieties being soon on the market.

THE GRINDING WHEEL AND GRINDING MACHINE IN THE MANUFACTURE OF AUTOMOBILES

The statements under this head must in the main be general, first on account of the limited amount of time, and in the second place, because quite frequently history is made in the automobile business between the time an article is sent to the printer and it is ready for distribution.

The following are important parts which depend upon the modern grinding wheel and grinding machine for the accuracy demanded:

Crankshafts.	Rear Axle Housings.
Piston Pins.	Worm Gears.
Piston Rings.	Spline Shafts.
Pistons.	Push Rods.
Cam Shafts.	Valves.
Eccentric Rods.	Bearings, both ball and roller.
Steering Knuckles.	

This list is not by any means complete. To mention all the parts of an automobile that come in contact with the grinding wheel would be to name almost every essential part, the possible exceptions being the sheet metal fenders, hood over the engine, radiator and the rubber tires; even the glass windshield, the springs in the cushion, enameled number plate, the clutch and brake pedals and the button to the Klaxon horn are ground.

The grinding wheel also has what may be called an indirect bearing on the manufacture of automobiles. The metal tools used in lathes, planers, boring mills, milling machines, and so forth, must be sharpened when they become dull. A great many of these tools are made of alloy steel which can only be satisfactorily shaped by using a grinding wheel. Stellite is a material which is rapidly coming into use. It, too, depends upon the grinding wheel to shape it as desired. When we consider this phase of the subject the importance of the grinding wheel is strongly emphasized and warrants one making the statement that present-day production would be only a dream if it were not for artificial abrasives.

There is a type of grinding machine known as the precision grinding machine. The word precision is used because machines of this type must be capable of producing work of great accuracy. The art of precision grinding has advanced very rapidly during the past few years, and the demand of the automobile manufacturer should get credit for a large share of the advance. Only a few years ago any one advocating the accurate grinding of shafts 5 in. to 6 in. long without table or wheel traverse would have been condemned as too visionary. This step in the art has long since been passed.

It is now possible to grind more than one diameter at one time with one wheel. This is an outgrowth of the use of very wide wheels taking extreme cuts without any traverse of the table or the wheel.

A conception of the refinement necessary in the modern grinding machine will become evident by considering the following:

A machine using a very wide wheel, say 10 in. or 12 in., must have great rigidity as well as be capable of producing refined work. Imagine the forces present when a wheel weighing 150 or 200 lb. (68 to 90 kilos) revolves on a spindle in plain bearings at 1000 to 1200 r.p.m. There must be accuracy to keep this spindle in perfect alignment so that the face of the grinding wheel will produce an absolutely straight cylinder, and the weight required in the base of the machine and the wheel slide to absorb all vibration caused by the revolving mass must be ample. Another factor which must be borne in mind is the resistance which is offered when the wheel is brought in contact with the work, as small particles of a very hard material are removed at an extremely rapid rate. It has been calculated that on a wheel 24 in. (60 cm.) diameter and 4 in. (10 cm.) wide there are 1,860,171,000 cutting particles coming in contact with the work each minute. The spindle bearings must be so closely adjusted that the boxes will be quite hot when the machine is in operation, in fact a temperature of about 140 deg. F. (60 deg. C.) is desirable.

Limits on the work being ground of 0.0005 in. (0.013 mm.) are very common, those of 0.00025 in. (0.006 mm.) quite common, and in some cases requirements are so exacting that less than 0.00025 in. (0.006 mm.) is demanded. It should also be borne in mind that when the work is reduced 0.00025 in. (0.006 mm.) the massive slide carrying the wheel spindle and the grinding wheel moves forward only half of this distance. If it were possible to split a piece of tissue paper into 12 thicknesses, the thickness of one of the resulting pieces would represent the motion of the wheel slide when the grinding wheel removes 0.00025 in. (0.006 mm.) from the work. Bear in mind that this accuracy must be maintained not only where very small cuts are taken but also under conditions where the object is to grind off as many cubic inches per minute as possible.

Many more interesting points could be given but it is hoped the few mentioned above are sufficient to have awakened a sense of appreciation of the modern grinding wheel and grinding machine.

The next time you look at the engine and transmission machinery in your car do so with a certain amount of reverence, and take a few moments from your busy life to reflect that a product of the electric furnace has made all this possible—the artificial abrasive.

The Norton Company,
Worcester, Mass.

Titanic Oxide Pigment

Considerable research work has been conducted by the Titanium Alloy Manufacturing Company, of Niagara Falls, N. Y., on the production of titanium compounds for use chiefly as pigments. In a patent granted to Louis E. Barton, Oct. 5, 1915 (No. 1,155,467), and in applications No. 23,520, filed April 23, 1915; No. 40,639, filed July 19, 1915, and No. 102,393, filed June 8, 1916, different methods are described for producing titanic sulphate or other base having a coating of minute particles of titanic oxide. The methods in general include precipitation in solution of the oxide upon particles of the "extender" or suspended material such as the above-mentioned titanic sulphate.

Another patent has just been issued to Mr. Barton (No. 1,223,357, April 24, 1917) and assigned to the Titanium Alloy Manufacturing Company, in which is described a method of producing the titanic oxide, which is stated to give a more desirable and purer product than previous processes. An intermediate product is first produced in solution, and this is then calcined to

produce the final material. The solution is prepared as follows, according to the patent specification:

"I first produce a titanic sulphate solution, in any convenient manner and from any titaniferous material; but I prefer to do this by dissolving in sulphuric acid the titanic acid product of the method described and claimed in Letters Patent No. 1,171,542, granted to Auguste J. Rossi and myself on February 15, 1916, because the titanic sulphate solution thus obtained is particularly free from impurities and contains little, if any, free sulphuric acid and about 11 per cent of titanic oxide. This, or whatever other solution I employ, I dilute until it contains, say about 3 per cent of titanic oxide. I have, however, found it preferable for the preparation of certain composite titanic oxide pigments and also to expedite the subsequent operations to use a titanic basic sulphate solution instead of the neutral solution first referred to.

"I therefore, preferably, convert the latter to basic condition in any convenient manner, such, for example, as by adding to such concentrated titanic sulphate solution lime slaked in five parts of water. The quantity of lime thus added in any case may be varied according to the results desired; but I have discovered that for the purpose of subsequently precipitating basic titanic sulphate an addition of lime chemically equivalent to 20 per cent of the total sulphate in solution is sufficient. After the addition thereto of what may be termed lime-cream, I allow the charge to stand for, say, from about one-quarter to one-half of an hour, during which I agitate it from time to time, if only for the purpose of insuring a more complete combination of the ingredients.

"The resulting calcium sulphate I then filter out and dilute the filtrate so that it shall contain, as in the previously referred to instance, about 3 per cent of titanic oxide."

Following the preparation of the solution, the suspended particles of sulfate or other base are then added, or precipitated, in the solution. Calcium chloride will precipitate an insoluble sulfate, as will other compounds which may be added, such as calcium hydrate, barium hydrate, barium sulphide, etc. So-called "extender pigments" may also be used, such as silica, barytes, gypsum, china clay or asbestine. These are insoluble in the solution and constitute the suspended material. Precipitants are added in aqueous solution or, if insoluble, in water as a thin paste.

"The proportions of the precipitant thus added will depend somewhat upon the desired composition of the final composite titanic oxide product. If the latter is to have a high titanic oxide content the precipitant should be added in quantity chemically equivalent to say 20 to 40 per cent of the total sulfate in solution, and, in that case, may be added either before, or soon after, starting electrolysis of the charge; but, if it be desired to add the precipitant in quantity equivalent to, say, as high as 40 to 80 per cent of such total sulfate, I find it preferable to do so in several installments during the progress of the electrolysis, since thereby presence of the free sulphuric acid (product thereof) is insured sufficiently to facilitate formation of the desired insoluble sulfates by reaction with the precipitant, and also to retain in solution iron or other impurities present. If, on the other hand, the base or extender material is to be mechanically added as such to the solution as in the form of an "extender pigment" above referred to, the entire amount may be supplied to the solution by a single charge and either before or immediately after beginning the electrolytic treatment, it being preferable in such case to comminute the precipitant as finely as convenient.

"My next step is to electrolyze the solution, or charge. To this end, I use an electrolytic cell provided with any convenient form of agitation adapted by its action to assist in keeping the particles of extender material in suspension in the solution. I prefer to accomplish the electrolysis by aid of passing an electric current through the charge directly from one to the other of a pair of therein supported, or therewith contacting, electrodes, preferably lead, the cell being without any diaphragm. While the voltage employed may be varied quite considerably, I have discovered that a current of from 5 to 10 volts and of a current density at the anode of about 30 amperes per square foot, gives satisfactory results. It will be noted that I thus utilize my discovery that in the required treatment, for my purposes, of the solutions employed a diaphragm, or a diaphragmed cell, is dispensed with.

"During the aforesaid electrolysis I heat, as distinguished

from boiling, my solution. Such heating, preferably up to from say 90 deg. C. to 95 deg. C., I effect in any convenient manner, as for example by injecting live steam. But I can obtain, in some instances, and according to conditions, passable results with temperatures a little lower than those mentioned. Higher temperatures may be used, even up to boiling, though such higher temperatures are, for reasons above referred to, and others, rarely, if ever, desirable.

"The result of the electrolysis, under the conditions described, is to precipitate basic titanic sulfate in the form of very minute particles, the which, in nascent state, and with, as I believe, concurrent adsorption phenomena, contact with, adhere to, and coalesce with, the insoluble particles of base, or extender materials, suspended in the solution, thus producing a composite precipitate which I then filter out, wash with water, and dry, thereby producing my exceptionally pure, intermediate composite titanic product which is of great utility for many purposes in the arts.

"This intermediate composite titanic product I thereafter, if desired, calcine, to complete dehydration, at from 700 deg. C. to 800 deg. C., thereby producing the final composite titanic oxide product of my present process, the which is of exceptional utility as a pigment in paint, and for other uses, it being freer from undesirable impurities than any other with which I am acquainted.

Glass Analysis

By E. W. Hagmaier

PREPARATION OF SAMPLE

Chip off corners of plate, allowing them to drop into a clean wedgwood mortar. Grind these to a fair degree of fineness, and sieve through a forty-mesh sieve, onto a sixty-mesh. Retain all that is held on the sixty for analytical samples. Take a portion of this from the sixty-mesh and grind to a powder in an agate mortar. The remainder on the sieve should be kept to make solubility tests, after being washed with 95 per cent alcohol and dried at 105 deg. C.

DETERMINATION OF SiO_2

Fuse one-half gram of the finely ground sample with two grams of potassium carbonate and one and one-half grams of sodium carbonate in a platinum crucible. Transfer the fusion from the crucible to a porcelain dish, dissolve with water, and then carefully acidify with hydrochloric acid and evaporate to dryness, paying particular attention that the salts do not creep over the sides of the dish.

Bake for about one hour at about 115 deg. C. When sufficiently dehydrated moisten with hydrochloric acid and add sufficient water, heat and filter. Catch this filtrate in an evaporating dish, and after giving the precipitate several washings with hot dilute hydrochloric acid place dish on bath and evaporate again to dryness. Wash the precipitate just obtained with hot water and hot dilute hydrochloric acid, catching the washings in a beaker. When the solution in the dish has gone to dryness treat as before, and then filter, catching the filtrate in the beaker, which already contains the washings from the first evaporation.

When precipitates have been washed sufficiently place them in a platinum crucible and ignite and weigh. When weight is constant treat the precipitate with a few drops of dilute sulphuric acid and several cubic centimeters of hydrofluoric acid and volatilize the silica. Ignite and weigh the crucible and obtain the amount of SiO_2 in the sample.

IRON AND ALUMINA

The residue remaining in the crucible after the silica has been removed is fused with potassium bisulphate and the melt added to the main filtrate. This filtrate is then brought to a boil and the iron and alumina precipitated with ammonium hydroxide. These are filtered off and washed, after which the combined precipitates are

ignited in a platinum crucible and weighed. The oxides are then fused with potassium bisulphate, leached out with water, acidified with sulphuric acid and a strip of copper foil is placed in the solution, and this is then boiled for half hour to reduce the iron, after which the foil is removed and the iron titrated with permanganate of potassium. The iron is calculated to Fe_2O_3 , and its weight is deducted from the total weight of the combined oxides found in order to obtain the amount of Al_2O_3 .

LIME

To the filtrate from the iron and alumina add several grams of ammonium chloride and about five cubic centimeters of ammonium hydroxide and bring to a boil. To this boiling solution carefully add a hot saturated solution of ammonium oxalate. When sufficient oxalate has been added to insure complete precipitation of the calcium, boil for about two hours and then filter, and wash the precipitate. If there is any appreciable amount of lime present redissolve this precipitate and reprecipitate, adding the filtrate from this second precipitation to the first main filtrate. When the precipitate is sufficiently washed dissolve it off the paper into the original beaker in which the precipitate was made with dilute (hot) sulphuric acid and titrate with N/10 potassium permanganate, and calculate the CaO .

MAGNESIA

The filtrate from the lime is completely cooled, after which ten cubic centimeters of a saturated solution of sodium ammonium phosphate are added; then add fifty cubic centimeters of ammonium hydroxide slowly, with constant stirring. Continue the stirring for about ten minutes, after which allow the solution to stand several hours, and preferably over night.

After having stood a sufficient time filter and wash the precipitate with dilute ammonium hydroxide wash, place the paper in the original beaker in which the precipitation was made, spreading it out to facilitate drying and allow the paper to dry. When thoroughly dry dissolve the precipitate in an excess of decinormal sulphuric acid and titrate the excess of acid with decinormal sodium hydroxide solution, using methyl orange as an indicator. Calculate to MgO . cc of N/10 acid times 0.004 equals per cent MgO .

ALKALIES

These are preferably determined by the J. Lawrence Smith method, which will not need an explanation here.

SODIUM SULPHATE

Fuse one or two grams of the finely ground sample with sodium carbonate and potassium nitrate. Leach out melt with water, acidify with hydrochloric acid, remove silica and precipitate the sulphates with barium chloride. Boil the precipitate of barium sulphate several hours, filter and wash and calculate to sodium sulphate.

SOLUBILITY TEST

Boil ten grams of the coarser sample for one hour with 100 cubic centimeters of distilled water, in a flask fitted with a reflux condenser. Cool, add methyl orange and titrate with N/10 sulphuric acid and calculate the result to Na_2O .

Buffalo, N. Y.

New Chemistry Building at University of Basel.—The beautiful new chemistry building at the University of Basel is fully described with drawings and photographs in the *Schweizerische Bauzeitung*, March 31, 1917.

The Production and Properties of Magnetite Electrodes*

By M. De Kay Thompson and T. C. Atchison

Magnetite electrodes were until recently extensively used at Chuquicamata, Chile, as anodes in the electrolysis of acid copper sulphate solutions. Chemically, they withstand the oxidizing effect of the current better than any other substance, but they have been practically given up on account of their extreme brittleness. "Duriron" has taken their place.

The object of the following work was to see whether the chief fault in these electrodes, their brittleness, could not be improved. A rumor had reached us that this could be done by the addition of a small amount of copper oxide to the magnetite, though we were never able to trace it to its source. The plan was to try the addition of this and other oxides and also to vary the heat treatment and measure the toughness of the resulting electrodes. On account of lack of time we were able to carry out only a part of this work.

These electrodes can doubtless be cast from fused magnetite, but this is difficult when working with small quantities. The following method was found very easy to carry out and to give a very good product:

A 3.8 cm. hole was drilled to a depth of 16.5 cm. in a graphite rod 5.1 cm. in diameter and 30 cm. long. The whole electrode was held in a vertical position by firebricks with a copper holder at the bottom where electric connection was made. The other electrode consisted of an electric light carbon, 1.3 cm. in diameter and 30 cm. long. This was held by an iron stand mounted on two iron pipes as rollers so that it could be easily moved. In series with this furnace was a carbon plate rheostat, an ammeter, and the secondary of a transformer which supplied the heating current. The voltage measured at the transformer terminals was 60 and the current was about 200 amp. The electric-light carbon was then lowered into the boring in the graphite until its end touched the bottom, an arc was struck and ground magnetite was fed in. This fused in the arc very rapidly and by watching the process through dark glasses it was easy to see when to add more magnetite. The boring was thus filled right up to the top and the electric light carbon was withdrawn gradually during the process. The first anodes were made without any attempt at annealing. When the upper end was nearly at the freezing point, there was always an evolution of some gas, causing a blow hole at that end. There were also occasional blow holes in other parts of the anode. There must have been some reduction to iron or to a lower oxide of iron, but it was so small in amount that it was not apparent. The fusion required about 30 minutes. After cooling, the anode was drawn out of the graphite tube. If it did not come easily a centimeter of the end of the tube was sawed off, so that the anode could be taken hold of, and so could easily be pulled out.

Attempts were also made to make anodes by passing an alternating current through the graphite tube and heat this to a temperature sufficiently high to melt the magnetite contained in it. There were evidences of reduction of magnetite to iron, however, and so this method was given up.

The method employed to test the brittleness of the anodes consisted in supporting them by two knife edges at the ends and applying a load at the center,

gradually increasing it until the specimen broke. This load is a measure of the toughness or brittleness of the material. The greater the length and the smaller the diameter of the rod tested, the more reliable is the result. Accordingly an attempt was made to make anodes only 2.5 cm. in diameter. They broke so easily when handled that we returned to the original 3.9 cm. diameter, but increased the length to from 24.1 to 26.6 cm. Allowing for an air hole and consequent weakness at the end, this length admitted testing with a 17.8 cm. span. After some preliminary trials with a larger machine and the use of lead shot in a tin pail as load, a small Riehle testing machine, capable of measuring up to 9000 kg., was found satisfactory when the load was applied very slowly by moving the belt by hand. The loads at which the specimens broke varied from 9 to 159 kg. Even though the measurement of these small loads may not have been very accurate, it is thought to be well within the precision of other experimental factors, especially the variation in brittleness due to the varying rate of cooling and the lack of uniformity in structure.

It was decided in this work to concentrate our attention to one oxide, and copper oxide was chosen. Specimens weighing from 1200 to 1300 gr., 3.8 cm. in diameter, and 25.4 cm. long were made from 99 per cent magnetite,¹ and varying amounts of copper oxide. The loads at the breaking point when applied at the center of a 17.8 cm. span were measured and taken as a comparative test of their brittleness. The results are given in Table I and Fig. 1.

TABLE I

Per Cent Copper Oxide	LOAD AT BREAKING POINT, KILOGRAMS			
	Single Observations			Average
0	11.3	17.3	20.4	19
1	18.2	26.3		22
2	18.2	43.1	50	39
5	36.3	42.2	47.6	50
10	52.2	58.1	59	56
20	104	130		117

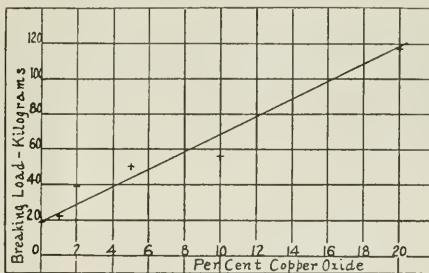


FIG. 1.

While these observations show great variations due to accidental causes, in the average values these are more or less eliminated, and there is an unmistakable decrease in the brittleness with increasing amounts of copper oxide.

The effect of annealing was next tested. The graphite tube in which the electrode was made was placed in a vessel 25 cm. in diameter and packed with asbestos. Three specimens of 5 per cent copper oxide were made. The time required for cooling was about eight hours. They were tested exactly as in Table I and gave 105, 151 and 102 kg., average 119 kg., as the breaking load, or an increase of over 100 per cent in the strength over those of the same composition which were cooled quickly. From external appearances they

*A paper read at the Detroit meeting of the American Electrochemical Society, May, 1917. The authors express their thanks to Professors H. W. Hayward and C. E. Locke and to Messrs. Freeman Clarkson and George Sutherland, for assistance and advice in connection with this work.

¹Obtained from Witherby, Sherman & Co., Fort Henry, N. Y.

cost of labor and plant per pound of good castings. As these are not all independent factors, economy may sometimes result from increasing some if others are thereby much reduced; thus, increased plant cost may save more in labor cost, and increase in bad castings might even be warranted by the great saving of heat and labor due to working faster. The best combination of these economies is, therefore, not always a simple matter to determine, and varies greatly with the local conditions. To obtain economy in heat, the ideal is not only to insulate as well as practicable, but also to heat and cast the metal in as short a time as practicable. From this standpoint the most perfect melting furnace is the electric fuse, in which the intended result is completed in such an exceedingly short time that the heat losses during that time are vanishingly small. With fuel heating too great a rapidity of heating involves higher chimney losses, hence a limit to the speed is soon reached. With electric arc heating there are high radiation losses from the arc, and from at least one, and sometimes both, electrode tips, as the arc must necessarily be kept above the pool of metal. But, in heating the metal by its own resistance, the heat can be generated below the surface, in the metal itself, thereby eliminating all heat transition losses. It is pointed out in the paper that the larger the amount of metal in a furnace the less the rate of heat loss per pound. In fixing the size the following points must be borne in mind: (a) When melting is the only object, the metal should be kept hot the shortest possible time, hence there should be used as small a furnace as is consistent with the amount of metal required for one casting. (b) When there is involved refining, mixing, uniformity of alloying, the taking of specimens for analysis while melted, or any other operation requiring time, then the larger the furnace the better. At the writer's suggestion a large foundry which casts wire bars is now melting tons of metal in a small electric furnace only large enough to hold a little more metal than for one bar.

As regards the shape, an approximate hemisphere is the nearest practical approach to the ideal for a furnace hearth. While the thickness of the insulation is of importance, the outside surface seems to be a more important factor than is generally supposed. White-washing, covering the outside with superimposed layers of thin sheet-iron, heating the outside of the furnace with a cheap fuel, were mentioned in this connection. Water-cooling must sometimes be resorted to, however, to guard against over-insulation and protect the walls from overheating.

Superheating of the metal is one of the important causes of waste of heat, and, with zinc alloys, there is, in addition, the loss in volatilization. Often superheating is merely done to supply the heat lost in transit from the furnace to the molds, mounting them on a sort of carrousel.

With a small high-speed electric furnace it would not be impracticable to bring the furnace to the sand molds. Heating the molds, especially when made of metal, also saves some heat, as it then costs less for heat than if it be supplied at high temperature from the superheat in the molten metal. Superheating may sometimes be done more economically by heating the stream of metal while it is being poured out of the furnace into the molds. This might be done by powerful blast flames along a prolonged channel, or electrically by causing the metal to flow through a carbon or graphite tube heated by resistance, or by passing a large, low-voltage electric current directly through the flowing stream. Superheating is sometimes resorted to for refining purposes; by making the metal very fluid the impurities will rise into the slag or dross. It is an

expensive way, but may sometimes be the simplest method. In a certain type of electric furnace this kind of refining is accomplished very rapidly and thoroughly by a peculiar, strong, upward circulation of the fluid metal, produced electromagnetically. Ingots cast from scrap metal cleansed in this way are preferred by those who remelt them for castings. The dirtiest old scrap metal refined by this "electric boiling" casts into clean ingots with a fine fracture. Melting in a partial vacuum, in some types of electric furnaces, may also tend to produce some refining, as it draws out suspended gases and may reduce the boiling points of some of the impurities enough to eliminate them by volatilization; but for brasses this would greatly increase the loss of zinc by volatilization. The losses of zinc in brass could be reduced in several ways: (1) By reducing the amount of superheat. (2) By heating only from the bottom so that the volatilized zinc condenses again in the cooler upper layer. (3) By heating under pressure, a method which is possible only in specially constructed electric furnaces. If a curve be drawn showing the costs of producing at various temperatures by means of combustion heat, it will be found that the cost rises slowly at first for the lower temperatures, but very rapidly for the higher ones, such as those required in the refining of steel. Too great a draft may supply more air than the fire can heat. With electric heat, however, the corresponding curve is very different, being more nearly a straight inclined line and up to temperatures about double the maximum obtainable by combustion. For the lower temperatures the cost is greater, but for the higher ones it is less. The two curves intersect, hence the cheapest method is to generate the low-temperature heat (up to this point of intersection) by means of fuel, and the higher temperatures electrically. In practice this means preheating the cold metal with fuel heat, say up to, but not above, the point where rapid oxidation takes place, and then melting and superheating the preheated metal electrically.

Dyestuffs

Society of Dyers and Colorists.—An account of the annual meeting of the Society of Dyers and Colorists which was held in Manchester, England, on March 30 is given in *The Chemical Trade Journal and Chemical Engineer* for April 7. In the course of his presidential address, which was devoted to the subject of patent-law reform, Dr. Alfred Réé, who was re-elected president, said that the number of well-trained chemists in this country was only one-fortieth of the number in Germany and one-fiftieth of the number in Switzerland. There was sufficient cause for dissatisfaction, because there could be no doubt that England should be better off industrially if the numbers were very largely increased. He did not suggest following Germany absolutely in this matter. What was good for her or for Switzerland was not necessarily good for England or for France. It was high time, however, that the old prejudice against the study of chemistry should be overcome. Much could be done by improving the remuneration of the well-trained chemist, though that was enormously better than it was a few years ago. The study of chemistry ought, he submitted, to be quite separate from that of the pharmacist. Without in any way decrying the latter, a well-trained chemist required a far longer and more thorough training and education, and some means should be found whereby the difference between them should be definitely established, as it was in other countries.

Our patent laws have been a serious deterrent to the development of the chemical industry. He had no hesitation in saying that their influence for evil had been far greater than could be realized except on a rather ex-

haustive examination of the whole question. Had there been no patent laws at all with regard to chemical processes and products, the progress in the British color and allied industries would have been quite satisfactory in the last forty years. To the bad effect on industry of the patent laws generally there was the further one with regard to the compulsory working of patents in England, especially foreign ones. Proposals for the compulsory working of patents, granted to persons who might afterwards work or manufacture the articles outside the United Kingdom, emanated from the Manchester Chamber of Commerce. Had the warnings of the Chamber been heeded years ago the position to-day and since the outbreak of the war would have been very different. Not only would the aniline color industry have been established on a firm and adequate scale, but the same statement would have applied to a number of other chemical industries with which high explosives were so intimately associated. It was, indeed, deplorable to what a serious extent the interests of the British chemical industry had been mishandled from a legislative point of view before the war. At the close of his presidential address, Dr. Rée presented the Perkin Medal of the Society to Prof. Arthur G. Green, formerly head of the Tintorial Chemistry Department of the Leeds University, and now director of the Coal Tar Chemistry Research Department of the Manchester School of Technology, in recognition of his valuable researches in dyestuff chemistry, and particularly for his discovery of primuline in 1887. This makes the fourth award of the medal, which was instituted by the society in commemoration of the late Sir William Perkin. It is awarded triennially for investigations, discoveries and inventions of high scientific or industrial importance, and the first award was made in 1908 to Professors Carl Graebe and C. Liebermann for their discovery of the artificial production of alizarine. The second award was made in 1911, to Prof. Adolph von Baeyer, for his pioneer work in the synthetic production of indigo; and the third, in 1914, to Count Hilaire de Chardonnet, the inventor of artificial silk.

Alloys

Alloys of Chromium, Copper and Nickel.—The growing interest in special acid resisting alloys and the many uses found for them have stimulated both the search for efficient materials of this nature and the study of the causes underlying their inertness. As a result of previous studies at the University of Illinois it has been shown that the almost perfect insolubility of certain alloys in nitric and other acids seems to be conditioned upon a proper mixture of chromium, copper, and nickel, together with smaller quantities of such added metals as tungsten or molybdenum. The University of Illinois Engineering Experiment Station has just completed a preliminary systematic study of the alloys of chromium, copper and nickel, and their properties. The work has been under the direction of Dr. D. F. McFarland, Assistant Professor of Applied Chemistry, and Dr. O. E. Harder, Fellow in Chemistry. The results are published in Bulletin No. 93 of the Experiment Station, just issued. A summary of the results and conclusions derived follows:

(a) Methods have been developed for making castings of alloys of chromium, copper, and nickel; and twenty-one binary and thirty ternary alloys have been prepared. From this part of the work the following conditions have been drawn:

(1) Castings of chromium and copper containing as much as 13 per cent of chromium can be prepared by melting and pouring the metals at about 1600 deg. C.

(2) Chromium-copper alloys containing 6.08 per

cent or more of chromium show a separation of chromium or of a chromium-rich constituent, if they are cooled slowly.

(3) If equal weights of chromium and copper are heated together to a temperature well above the melting point of chromium and slowly cooled, the alloy is not homogeneous, but consists of two layers; the lower rich in copper, and the upper rich in chromium.

(4) The addition of nickel to alloys of chromium and copper tends to prevent the separation of the chromium or chromium-rich constituent; when the amount of nickel is more than three times the amount of copper present, the alloys become practically homogeneous.

(b) Physical and mechanical tests have been made with the following results:

(1) The specific gravity at 25 deg. C. of the alloys tested varies from 8.92 to 7.89 and decreases with an increase of chromium.

(2) The Brinell hardness number varies from that of pure copper to that of tool steel and increases with an increase of chromium.

(3) The modulus of elasticity of the sixteen alloys tested varies from less than 15,000,000 to more than 40,000,000 lb. per square inch. Generally it increases with an increase of chromium.

(4) The ultimate tensile strength of the eighteen alloys tested varies from less than 10,000 to more than 50,000 lb. per square inch.

(5) The reductions and elongations are small in all cases.

(6) The stress-deformation curves are similar to those of cast iron.

(c) More than three hundred corrosion tests have been made. Results show that:

(1) The amount of corrosion is not proportional to the strength of the acid or base.

(2) A triangular system of plotting shows certain fairly well-defined areas which are highly resistant to corrosion.

(3) Not only the alloys in the region approximating the composition of the alloy developed by Professor Parr are highly non-corrodible, but others have shown equally good resistance to corrosion. In general the ternary alloys are less corroded than the binary, though there are some exceptions.

(d) An attempt has been made to find some relation between the relative electromotive forces obtained by placing the alloys in contact with 4 Normal sodium chloride solution and their relative resistance to corrosion, but no such relation has been found from the experimental data obtained.

(e) A microscopic study of the alloys has been made and the following agreements with earlier investigators have been found:

(1) The results agree with Voss' conclusions that chromium and nickel form a series of solid solutions (mixed crystals) over the range of 100 to 50 per cent of nickel and that they form a eutectic, or, as Guertler called it, a pseudoeutectic, containing about 42 per cent of nickel.

(2) The results on the copper nickel series agree with those of Guertler and Tammann in showing a continuous series of solid solutions.

(3) All nickel-rich alloys, both binary and ternary, show well-defined polyhedral crystals.

(f) In general the results indicate that the alloys of chromium-copper-nickel which show possibilities of becoming of commercial importance are limited to certain rather well-defined ranges of composition. In Fig. 1 in the bulletin is shown what seems to be the most promising field for future investigation. In the nickel-rich corner of the diagram the alloys have very large

polyhedral crystals and a coarse texture, and have usually developed blow-holes in casting. There is a possibility that the texture can be improved by the addition of a fourth metal as Professor Parr has done by the use of tungsten or molybdenum. The alloys containing large percentages of chromium have such high melting points and are so hard to prepare that, unless they find special and important applications, there is little chance of their being used commercially. Alloys containing large percentages of copper with chromium show such a marked segregation that they do not machine well and their mechanical properties are poor. The region which promises best from the mechanical and physical standpoint is also, as a general rule, highly resistant to corrosion in the various solutions tested.

Fertilizers

Artificial Fertilizers.—In an article on this subject in the *Journal of the Society of Chemical Industry* for March 15, 1917, A. R. LING gives a review of the present use and future prospects of artificial fertilizers throughout the world. He first takes up a discussion of the phosphate fertilizers and points out that while the world's production of superphosphate increased from 5,130,900 metric tons in 1903 to 9,604,260 metric tons in 1910, and has increased further since that time, it has not nearly reached its limit as yet. There is great need for superphosphate in the British Empire, especially in Australia and South Africa; Canada will also probably need it in the future, although not using any now. Russia and Roumania will also need large quantities. The United States produced in 1910 over one-third the total production. In discussing basic slag, the author points out its value for grass land and states that outside of Europe it is not in use. In the United States it is not made as the open-hearth process in use here gives an acid phosphate slag, part of which is used for various purposes, but a large part of which goes to waste. The question of how much artificial fertilizer can be used per acre is of great importance to the manufacturer, as it gives him information as to the extent of the demand that might be created. The following table, prepared by the author, shows the amounts used per acre in different countries. Belgium is shown to be the most intensively cultivated, with the United States standing higher than is generally believed:

TOTAL AMOUNTS OF ARTIFICIAL FERTILIZERS USED IN THE DIFFERENT AGRICULTURAL COUNTRIES OF THE WORLD

GROUP I			GROUP II		
	Metric Quintals per Hectare	Cwt. per Acre		Metric Quintals per Hectare	Cwt. per Acre
Belgium.....	2.74	2.18	Netherlands.....	1.96	1.56
St. Maurice.....	2.19	1.75	Germany.....	1.68	1.34
Luxemburg.....	2.02	1.61			
GROUP III			GROUP IV		
	Metric Quintals per Hectare	Cwt. per Acre		Metric Quintals per Hectare	Cwt. per Acre
United Kingdom.....	0.7-0.9	0.6-0.7	Sweden.....	0.53	0.42
U. S. (S.).....	0.87	0.70	Ireland.....	0.44-0.50	0.35-0.40
Switzerland.....	0.60	0.48	Japan.....	0.48	0.38
France.....	0.57	0.46	Portugal.....	0.36	0.29
Italy.....	0.57	0.46	S. Africa.....	0.29	0.23
Denmark.....	0.57	0.46	Norway.....	0.29	0.23
Australia.....	0.55	0.44	Austria.....	0.29	0.23
			Spain.....	0.14	0.11
			N. Zealand.....	0.13	0.10
			Hungary.....	0.10	0.08

Recent Metallurgical and Chemical Patents

Iron and Steel

Duplex Steel Process.—A duplex steel process which has for its object the prevention of breaking and cracking of the ingot surfaces during rolling is patented by FRANK D. CARNEY and LEWIS B. LINDEMUTH, of Bethlehem, Pa. The steel is first treated in the Bessemer converter and then in a basic lined open hearth. During the whole of the refining process a slag is carried in the basic open-hearth furnace with a sufficient content of manganese oxide, so that manganese may be reduced from the slag and enter the metal. The metal will contain 0.20 per cent and over of manganese. To obtain this condition the slag in the basic open hearth must contain not less than 10.0 per cent of manganese oxide. In the duplex process, manganese in the pig iron charged into the Bessemer converter, is eliminated early in the blow, except with ores containing 3 to 5 per cent manganese, which are not common except in Sweden and Norway. The charge then of blown metal to the open-hearth furnace will contain from a trace to 0.05 manganese. By then adding ferromanganese or manganese ore in sufficient quantity the conditions above mentioned can be obtained. It is claimed that this method prevents the absorption of iron oxide by the steel which destroys, to some extent, the good rolling qualities of ingots cast from it. (1,223,030, Apr. 17, 1917.)

Tanning

Electrotanning.—A process of electrotanning is patented by LORENTZ A. GROTH of London, England. Hides or skins are treated according to this process in a unit of six separate tan-pits arranged in line, the treatment lasting for one week in each tank. The complete treatment takes six weeks. Different tanning solutions and different current densities are used in the various tanks, the nature of which are not mentioned. It is stated that the tanks contain aqueous solutions of the ordinary ingredients used in the various processes prior to, and during the tanning. An agitating mechanism is used which agitates the hides horizontally and does not expose them to the injurious action of the oxygen of the air. The following claims are made for the process:

"Observations during many years of research and costly experiments, not merely in the laboratory, but more often upon a commercial basis with packs of hides, and skins, necessitating also the consideration, even of the smallest detail, as all of them offered difficulties of more or less severe nature, have enabled me to simplify my former system of electrotanning by dispensing with all the usual lime-pits, color pits, handlers, and layers, using only a small number of suspender pits, with a few soaks admitting of any blend or mixture of tanning material being employed, with a finishing strength of about one-tenth of that generally used, and equally applicable to all kinds of leathers; for vegetable or mineral tannages, or for a combination of both, resulting in the reduction of the time of tanning to one-sixteenth; the working capital by 80 per cent., and the cost of production by 50 per cent, while the quality of the leather is unsurpassed by reason of its uniform tannage; and as the tanning process is almost automatic in its working, great economic results are obtained." (1,222,861, Apr. 17, 1917.)

Aluminium Carbide

Manufacture of Aluminium Carbide.—A process for the production of aluminium carbide by heating alumina with the necessary carbon in an electric furnace is patented by MAURICE BARNETT and LOUIS BURGESS of New York City. Alumina, or an oxygenated

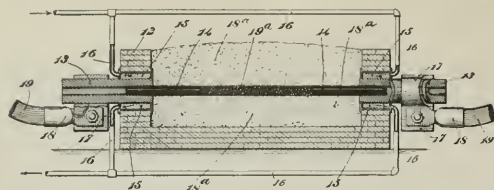


FIG. 1—SECTION OF ALUMINIUM CARBIDE FURNACE

ore of aluminium is crushed to about eight mesh, and mixed with carbon (which may consist of petroleum coke) of the same fineness, in the proportion of two parts of alumina to one part of carbon. Petroleum residues from the distillation of petroleum with aluminium chloride may be used. These residues contain alumina or aluminium chloride, probably in combination with asphaltic matter. The aluminium chloride may be decomposed by treating the residues with water and heating, which has the effect of hydrolyzing the aluminium chloride with the production of hydrochloric acid and alumina. By calcining the mass a residue may be obtained useful in the production of aluminium carbide, after suitable additions are made to bring the alumina and carbon to the proper proportions. After mixing the charge it is placed in an electric furnace such as shown in Fig. 1. The charge is shown at 18a, and reaches up to or slightly below the level of the bottom of the electrodes. A carbon core 19a, is then placed between the electrodes, and the furnace then filled to the top with the charge. The charge is brought to a temperature of 2000 deg. C., when aluminium carbide will be formed. This point can be told by the appearance of a blue flame of carbon monoxide, over the surface of the charge. The current strength can be successively increased up to this point. If the current is too strong, however, there will be an immediate volatilization of metallic aluminium, which will burn in the air with a bright flame, giving off clouds of aluminium oxide. When the operation is finished the charge is cooled and broken up, and the aluminium carbide will be found in compact masses through the charge. (1,222,593, April 17, 1917.)

Oxygen and Hydrogen

Generation of Oxygen and Hydrogen.—LÉO PAUL SÉBILLE of Providence, R. I., patents a method of generating and storing oxygen and hydrogen gas which is stated to do away with gasometers and compressors. The usual oxygen and hydrogen generating apparatus is provided with a gasometer for receiving the gas as generated from the electrodes, and compressors are employed for receiving the gas from these gasometers and placing the same under the desired pressure in suitable storage tanks. In this apparatus the usual electrolytic gas generator is employed, and the oxygen and hydrogen are conducted to separate float valves, and from these valves to pressure storage tanks. The float valves work automatically and equalize the pressure in the cell in both oxygen and hydrogen compartments. The pressure in the cells sometimes becomes higher on the oxygen side than on the hydrogen side or vice versa, thereby blowing out the sealing liquid electrolyte and permitting the two gases to mix which may cause an explosion. With the use of these float valves this condition is claimed to be obviated. (1,222,809, April 17, 1917.)

Treatment of Liquids

Electrical Liquid Treatment.—A process of treating liquids, sewage, etc., for the removal of incrustating

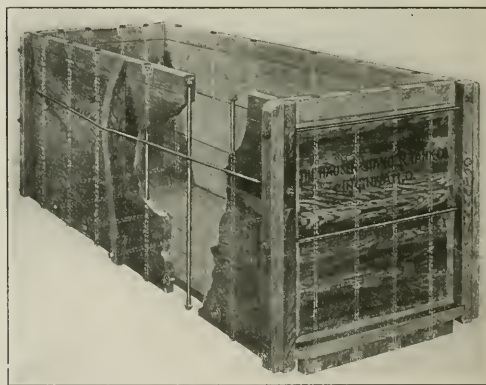
salts, for softening, or for removal of colloidal or suspended matter is patented by C. P. LANDRETH of Philadelphia, Pa. Incrustating salts such as soluble salts of calcium, magnesium, etc., are removed by adding sodium carbonate, calcium hydroxide, barium hydroxide, sodium hydroxide, or potassium hydroxide and passing electric current through the liquid, before, during, or after these additions. The current is stated to stimulate the precipitation of insoluble salts of calcium, magnesium, etc. A soluble hydroxide is used to remove "temporary hardness" and a soluble carbonate to remove "permanent hardness." Finely divided suspended matter such as in sewage is removed by adding alkali hydrate and passing current through. (1,222,637, April 17, 1917.)

An Improved Wood Tank for Chemical Plants

The alkaline or acidic solutions used in practically all the industries where plant processes are based on chemical engineering require containers that combine strength, economy of space required, and material that withstands the action of the particular chemical or solution in question.

Of course, in some cases glass enameled or sheet metal or cast tanks are absolutely necessary, but in a majority of instances it is found that properly made wood tanks of selected material will answer the purpose just as well and at a great saving in cost and maintenance.

The Hauser-Stander Tank Company, of Cincinnati, Ohio, one of the first and most successful manufacturers



PERSPECTIVE VIEW OF WOODEN TANK

of wood chemical tanks, uses some interesting construction features, especially in "square" tanks. Each square or rectangular tank is braced with a longitudinal iron truss-rod on each side which not only effectively prevents any warping or giving of the tank sides, but takes up practically no additional space—a valuable consideration in a chemical plant.

By means of vertical metal rods through the side and end boards with nuts for tightening, it is an easy matter to make the tanks tight after being empty for a time. The particular feature is that the nuts are at the bottom, with the rods running through the wood, while the tops of the rods are countersunk, as shown, and the hole tightly plugged with a compressed wood plug, so that the liquid cannot reach and corrode the rods. Malleable washers are used where the rods have purchase on the wood. Another feature is the hardwood top piece on all four sides of the tank, thus giving greater wear where it is needed.

Production of Hydrogen by the Iron Contact Method

By Harry L. Barnitz, Ph.G.

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One of the methods that has found favor in recent years for the production of hydrogen in installations of large commercial capacity is the so-called "iron contact method."

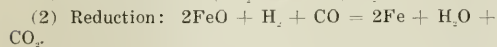
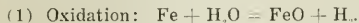
The generating elements employed by this method are coke and water, and through them hydrogen can be produced of almost "chemical purity," i.e., of a purer grade than by many other technical processes for large production excepting electrolytical.

The iron contact method is cyclic with respect to the "iron contact mass"; that is, this iron contact mass is used over and over again. If red hot iron is sprayed with a jet of steam, the iron is oxidized and forms iron oxide, while hydrogen is liberated. If the iron oxide thus produced is treated with reducing gases, such as generator gas, water gas or illuminating gas, the iron oxide is reconverted into sponge iron.

All these reducing gases consist chiefly of a mixture in varying quantities of carbonic oxide, hydrogen and hydrocarbons.

For instance, the commonly employed water gas, which is easily produced by means of coke and steam in producers of large working capacity (say up to 100 cubic meters per hour), gives a theoretical mixture of 50 per cent CO and 50 per cent H. In practice, however, this gas always contains large quantities of impurities, emanating from the coke during the process of generation, averaging about 6 per cent N, 4 per cent CO and 2-3 per cent hydrocarbons and sulphides.

The reactions used in the iron contact process may be represented by the following formulæ:



It will be observed that equation (2) is exactly the reverse of equation (1) at least as far as steam is concerned.

The reaction takes place at the surface of the "contact mass." Only where the fresh gases enter, a powerful and far-reaching reaction generally takes place, while the reaction generally decreases in intensity in the direction of the outlet of the gas.

Compact iron, such as waste or filings, is little suited as contact substance for the process, but iron oxide, either artificial or natural, e.g., iron oxide clay briquettes or iron ore, are eminently suitable. All these substances become more or less porous during the reducing process.

Theoretically speaking, the contact mass could be used over and over again indefinitely in accordance with the before mentioned formulæ so that an unlimited quantity of hydrogen could be produced by means of a limited quantity of contact mass.

In practice, however, a limit is placed to the life of the contact mass by the fact that as it is only the surface of the latter that is being acted on, the substance gradually becomes impregnated by the dust, silicic acid and sulphides liberated by the gases. These impurities form a layer on the surface diminishing the reacting capacity, so that the yield of hydrogen is gradually lowered and other disadvantageous combinations take place.

It is necessary, therefore, to renew the contact mass periodically, say after the plant has been in operation for from 8 to 30 days.

The principal difficulty with the iron contact method arises from the fact that a considerable amount of heat is absorbed during the various stages of the process by the chemical reaction. It is therefore not easy to keep the contact mass at a correct temperature without overheating.

If overheated the contact mass loses its porosity, cakes and even melts. This renders the replacing of the contact mass difficult or even impossible. The action of the gases becomes defective and the yield of hydrogen falls considerably, as channels and cavities are formed which can no longer be acted upon regularly by the gas and steam.

As the iron contact method is very old, all kinds of suggestions have been made in the course of time in connection with the practical method of dealing with this process.

A voluminous mass of patent literature on this subject is in existence. Only the most important of these patents, most of which have long ago expired, are here passed under review.

Giffard, who made the method public in 1878, may be considered the discoverer of the method. He employed a shaft filled with ore which he heated and reduced by means of gases coming from a producer connected with the shaft and which passed through a dust chamber, in order to remove the particles of dust introduced during the operation. The defect of this system was that the ore was easily contaminated by the impurities contained in the gases and that a sufficiently high temperature could not be maintained.

In 1889 Claus (English Patent No. 50) published a method for the production of hydrogen in a shaft furnace. He too employed "porous though solid blocks of iron oxide" which he alternately reduced with water gas and oxidized by means of superheated steam.

Walker's English patent 8373, dated 1890, describes the operation of the contact method in iron retorts, which were heated in a retort furnace from the outside. He employed water gas for the reduction.

In 1892, the firm of Krupp published various improvements of the process (D. R. P. No. 73,978) which, however, did not produce satisfactory results and were ultimately rejected.

Iron ores were employed in heated shafts or retorts and attention was drawn to the importance of employing reducing gases as rich as possible in hydrogen with a minimum of hydrocarbon.

Stracke returned in 1893 to the Giffard shaft furnaces (German Patent No. 77,350) and filled a shaft furnace with layers of "iron, iron oxide and ore in any form," heating and reducing the whole by heated generator gas or water gas which he introduced through the ore from the generator. He used charcoal in the generator in order to avoid the formation of sulphur compounds while producing exceptionally pure gas. The waste gases formed during the process of reduction were completely consumed in a superheater with fire-proof cage-work which served to raise to a high temperature the steam used in producing the hydrogen. Here too the heating was insufficient.

Schimming took out a German patent No. 95,071 for the preliminary heating of the reducing gases which he achieved by blowing air into the reducing shaft in order to cause combustion of a portion of the reducing gas. This method had the grave defect of overheating and melting the ore at the entrance, while the ore further away was not sufficiently heated. He tried to remedy this defect by mixing pieces of fire brick with the contact mass in order that the former might retain a portion of the heat, but the system involved serious drawbacks.

Caro in German patent 249,269 tried to overcome the want of uniformity in the heating by introducing air to the ore mass at various points during the reducing process. It is evident that under this system the reducing capacity of the gases was seriously affected, so that the yield of hydrogen was altogether too low.

Lewis's English patents 4184 and 20,752, dated 1890 and 1891, once more describe the iron contact method in detail. He proposed to lay a retort with iron contact mass directly through a water gas generator, which was technically hopeless owing to the consequent overheating. He proposed for the first time to employ porous briquettes made of iron oxide and clay or asbestos and then pressed and burned. He employed water gas for reducing, justly pointing out that the use of such gas rich in hydrogen greatly accelerated the process of reduction.

Hills describes in his English patent 10,356, dated 1903, the production of hydrogen by the iron contact method which he proposes to carry out in iron retorts. Unimportant improvements in the apparatus employed in the already well known process were patented by him. He used water gas for the reducing process.

Elworthy, in German patent 64,721, dated 1905, discusses the contact method exhaustively. He notes as the chief defects the tendency of the mass to melt and the choking of the retorts. He proposes to overcome this difficulty by using furnaces in which the spongy iron is contained in specially constructed fireclay holders. The use of iron in lumps of varying size is taken for granted. By "iron" he always means spongy iron produced by reduction from iron oxide or iron ore, as, he explicitly states in his English patent 12,461, dated 1902, he employs water gas for the reducing process.

Lane repeatedly constructed installations in Russia, France and England about 12 to 14 years ago on the iron contact method. He used chiefly briquettes similar to those suggested by *Lewis*, made of iron oxide and clay which were reduced by water gas in iron retorts, in large iron retort furnaces. The installations proved, however, to be of inferior working capacity as in the case of the proposals made by *Walker* (1890) and *Hills* (1903) and were nowhere a success.

The International Hydrogen Company whose shares are held by the Berlin Anhalt Machine Construction Company of Berlin, thereupon "discovered" the identical method for the hundredth time. The result was the same as in all other previous cases.

The inevitable difficulty of the retort system lies in the fact that the retorts are destroyed by fire after being a short time in operation (about six weeks) besides being choked by the ore.

In a large installation now in operation every charge for the 32 retorts for two furnaces with a capacity of 100 cubic meters costs about \$3,000.

As these retorts produce 100,000 cubic meters before being rendered useless by fire, one cubic meter of hydrogen costs for the replacing of retorts alone $\$3,000 \div 100,000 = 3$ cents. Apart from the high cost of production involved in the production of hydrogen by the retort method, other drawbacks, such as continuous repairs, loss of hydrogen by waste, interruption of operating plant, excessive, unbearable heat, and early destruction of the furnaces are so serious that the system is not to be recommended.

The mere fact of the imperfect preparedness for operation makes it unsuitable for airship purposes, as the furnaces have to be heated gradually for several days before they begin to produce gas. The heating of the retort furnaces entails the use of a special system of coke firing, built in the retort furnaces, and involves the use

of a considerable amount of coke (about 1200 to 1500 kilos per furnace daily).

The oldest system employed by *Giffard*, already referred to, undoubtedly possessed important advantages over this system, but the difficulty of heating was a very serious one as is shown by the above mentioned extracts from the patent literature on the subject.

Recently, however, after exhaustive experiments, many of the difficulties connected with the rational carrying out of the iron contact method in large industrial plants have been to a great extent overcome by the vertical cylinder process and installations.

The method has now been so much improved by the application of entirely new principles that it meets to a certain extent the requirements of a process adapted to large installations, such as rapidity in getting the plant into working order, more certainty of operation, and simplicity. The vertical cylinder generator is distinguished by separate heating and contact chambers communicating with each other. The former serve for the uniform heating of the contact mass, as well as for the super-heating of the steam. The heating takes place at intervals, yet it is continuous, because when the heating is discontinued, the super-heating maintains the temperature of the contact chamber by its radiation and continues to heat the contact mass.

The application of this principle explains the high generating capacity of this type of generators.

Owing to the separate chambers, the vertical cylinder generators may further be heated directly by the still combustible waste gases liberated during the reducing process. They require therefore no expenditure for heating material or special heat generators with workmen in attendance, as they are self-heating. This gives some advantage of an economy hitherto unattained. Losses of hydrogen, such as are inevitable by the retort process, are avoided by the use of the vertical cylinder type of generators, as no glowing particles of iron peel off the exterior of the apparatus, under pressure, owing to the generator being lined with fireclay.

Necessary repairs can be executed in a few hours without any lengthy interruption of work, as the inner parts can be easily withdrawn and replaced by a block and pulley arrangement. Any kind of reducing gas may be used in the vertical cylinder system of generators but it is best to employ water gas or half water gas.

A special arrangement further renders it possible to heat the contact mass, both directly and indirectly during the reducing process by means of which uniform heating is secured.

Many of the defects incident to former installations are avoided in the vertical cylinder system by replacing the contact mass in comparatively narrow circular layers which also secures uniform heating, reduction and oxidation by the corresponding streams of gas.

Giffard suggested ore as a contact mass. When properly treated, specular iron ore, red hematite and iron oxide hydrates have generally been found suitable. The use of purple ore was protected by patent 220,889 and that of sparry iron ore by patent 241,669 (dated 1911). The former has the disadvantage of containing too much sulphur and cakes easily, while the latter often melts too easily.

Their use, therefore, offers no advantages. As a rule briquettes are too slowly owing to their defective porosity.

According to German patent 244,732 taken out by the International Hydrogen Company, spongy iron free from carbon can only be produced by reduction and out of it pure hydrogen, when instead of the usual water gas, a gas consisting chiefly of hydrogen, but absolutely free from hydrocarbons, is employed.

In practice this assertion has not been found to be warranted. Besides, the fact is unimportant, as there exists no practical methods of producing such a gas.

The Badische Aniline & Soda Manufacturing Company has even admitted in a recently announced patent that spongy iron produced by a reduction from iron ore by means of coal in Sweden for smelting purposes is suitable for the preparation of hydrogen.

Experts have long been aware that the maintenance of a proper temperature is indispensable for the production of spongy iron free from carbon. If this is done, any reducing gas, even pure carbonic oxide may be used for reducing, but water gas has the advantage of acting more quickly as has been decided by experts who investigated the matter several decades ago.

Many defects of the iron-contact method for production of hydrogen have been overcome in recent years, but there still remain further refinements to bring the process to its highest efficiency.

Surface Combustion Applied to Galvanizing

By William J. Harris, Jr.

The use of manufactured gas for heating galvanizing baths seems to have been seldom attempted in the past, and the few installations which have been tried have been unable to meet the competition of coke on a cost basis. The installation which we are about to describe is therefore particularly interesting because of the fact that, in addition to satisfactory operation in every particular, it practically met the cost of the coke fuel including actual saving in labor.

As is no doubt well known, the usual type of galvanizing bath is a rectangular steel tank of riveted or welded construction. The dimensions vary, according to the character of work to be done, but may be anywhere from 2 to 4 ft. in depth by 2 to 6 ft. wide and 5 to 20 ft. long. Because of the settling of the so-called "dross" to the bottom of the tank, it is impossible to apply heat directly to the bottom. Hence, the usual arrangement is to set the tank on a brick or sand foundation, and to build a brick setting around it with space for a coke fire between the sides of the tank and the inside of the setting. This space may be from 6 to 18 in. wide, depending on the amount of heat required, and on two or four sides of the bath, depending on whether it is long and narrow or approximately square in shape.

Fig. 1 shows a coke-fired bath. It is used for coating steel sheets of varying gages from No. 30 to No. 18, and



FIG. 1—NEAR VIEW OF COKE FIRED BATH



FIG. 2—SECTION OF CASING WITH BURNERS INSTALLED, READY FOR BRICKWORK

from 24 in. to 48 in. wide and 6 ft. to 12 ft. long. After "pickling" to remove the scale the sheets are run through the melted zinc by a "coating machine" consisting of a series of gear-driven steel rollers and a suitable framework immersed in the bath. In coming out of the bath the sheets are carried along an air-cooled conveyer about 100 ft. long. It will thus be seen that the operation is continuous and that a high rate of work is essential to economical production. The weight of sheets coated varies from 20 to 40 tons per day of 24 hours, using from 6000 lb. to 8000 lb. of zinc in the same period.

The gas-fired bath is being used for the same kind of work as that just described, and was originally designed for a coke fire. Instead of using a plain brick setting, however, it had been provided with cast iron casings which were lined with brick and placed about the steel tank after it had been put in position. This more durable construction was designed to make it possible to renew the tank without having to rebuild the brickwork, and it was found particularly well adapted to the installation of the standard "impact type" of surface combustion burners. Fig. 2 shows a section of the casing with burners installed ready for the brickwork. The casing as originally made for the coke fire consisted of four straight sections for the sides and four corner pieces. The side sections being set closer to the tank for the gas installation made it necessary to abandon the corner pieces and fill in the space with brick. This is shown in Fig. 3, which is a view of the completed installation. Fig. 4 is a plan and cross-section showing location of burners, refractory bed, etc.

The "high pressure" gas system was used. This operates normally on a maximum gas pressure of 10 lb. per square inch and atmospheric air. In this case, however, the gas company was able to supply the gas at 4 lb. pressure. Hence the inspirators were specially designed to operate on 3 lb. at the normal working rate. A motor-driven gas booster was installed for use should a higher rate be desired and in case the service pressure of the gas should drop. Ordinarily this is not needed, and operating costs are thereby materially reduced. The proportioning of gas and air is entirely automatic without the use of governors or any appliance with moving parts. Temperature control is obtained by the simple adjustment of the gas valve (marked "V" in Fig. 3). This is the only valve on the apparatus.

The burners on each of the four sides of the setting are connected to separate inspirators which are in turn connected independently to the high pressure line. The heat on each side of the bath can thus be regulated independently or any set of burners turned off entirely if desired. A low reading spring pressure gage (marked

"G" in Fig. 3) on each inspirator indicates directly the gas pressure at which it is operating. As the proportioning of the "mixture" is automatic and uniform, this pressure gage gives an accurate and convenient means of temperature control. Thus, if 2 lb. pressure is found sufficient to maintain the required temperature at a certain rate of work, these conditions can always be duplicated or changed to meet new conditions without "guessing" at what the burners are doing.

The old coke-fired bath (Fig. 1) measures 7 ft. x 7 ft. x 44 in. deep with a capacity of 69,000 lb. of zinc, while the gas-fired is 6 ft. x 7 ft. x 44 in. deep with a capacity of 60,000 lb. of zinc. The capacity of steel coated per day is, however, the same, and the fuel consumption was figured on this basis. Coating thirty tons of steel sheets and melting 8000 lb. of zinc, the coke used was found to be 4000 lb. per day of 24 hours. The entire time of one man was needed to wheel the coke from the storage bin and fire the furnace. At \$5.50 per ton for the coke and 20 cents per hour for labor, this figures \$15.80 per 24 hours. The gas installation was sold on a guarantee that, when doing the same work as above (30 tons steel and 8000 lb. of zinc), the gas consumption would not exceed 40,000 ft. of 600 B.t.u. gas per 24 hours. At the prevailing rate, this figured \$16.40.

On actual test immediately after the installation was completed 28,000 lb. of steel were coated in 12 hours with 19,000 ft. of gas, or at the rate of 28 tons with 38,000 ft. per 24 hours. The temperature of the bath was maintained at about 840 deg. Fahr. and new zinc was added at the rate of 6200 lb. per 24 hours. It was not possible to run at the maximum rate because sheets of a heavy enough gage to give the required weight were not obtainable. Subsequent reports indicate that the efficiency of the gas fire increases at higher rates of work and that the guarantee has been safely met.

When the bath is not in use the coating machine is withdrawn and the temperature maintained at about 810 deg. to 820 deg. with 650 cu. ft. of gas per hour. Under these conditions, the burners on two sides only are used, and by closing some of the vents in the brickwork, the flue gases are made to circulate around and come out on the sides where the burners are turned off.

It will be noticed that the fuel costs given above are for normal conditions. As a matter of fact, the high grade foundry coke which is required for this work now costs around \$8 or \$9 per ton and is practically unob-

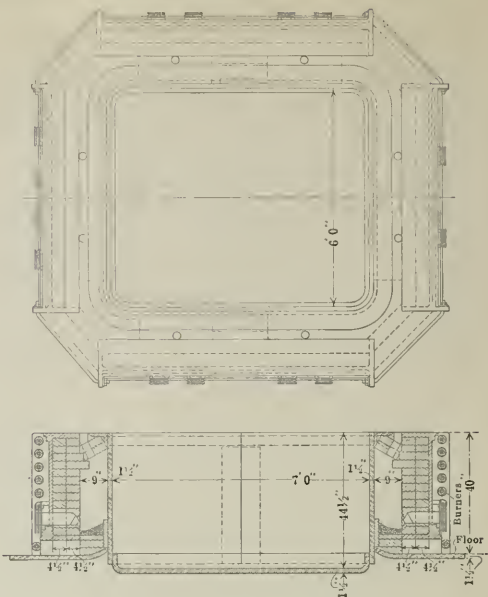


FIG. 4—PLAN AND CROSS-SECTION OF FURNACE

tainable at that. As a result of these conditions and the very satisfactory results with gas a second coke bath is to be changed over.

This installation was made at the plant of the Chapman Steel Company, Indianapolis, Ind., and was designed and installed by The Surface Combustion Company of Long Island City, N. Y.

Engineering Department, The Surface Combustion Co.,
Long Island City, N. Y.

Utilizing the Waste from Coal Mines in the Pacific Northwest

Some interesting data have been obtained by the Puget Sound Traction Light and Power Company of Seattle, Wash., in their experimental plant with the burning of pea coal. The following information is extracted from the report by Mr. Henry Hull of the company, which was published in the Puget Sound Electric Journal, the company's house organ, for April, 1917.

"There are within a hundred miles of Seattle numerous coal mines with thousands of tons of fine coal piled up which at present is unmarketable and which should be available slightly above the cost of transportation.

"This coal is a lignite variety particularly adapted to use in powdered form due to the high volatile constituent and the very high fusing point of the ash.

"The foregoing characteristics are very important inasmuch as a high carbon coal requires very fine pulverization and carefully designed furnace to maintain the high temperature until ignition is complete, and a low fusing ash will, when carried in suspension, cling to the tubes of the boilers, close up the flame space and make its operation impossible.

"To prepare this coal for burning it must first be thoroughly dried and moisture content reduced to approximately 1 per cent before it can be properly pulverized. It must then be pulverized to powder form, where approximately 85 per cent will pass through a

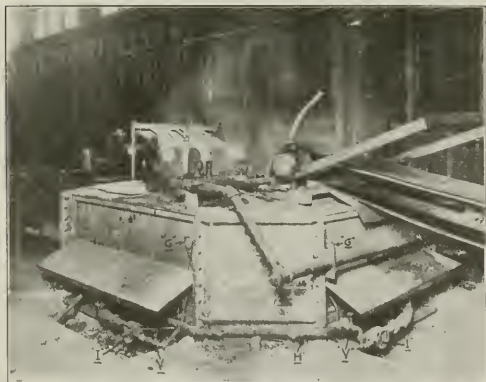


FIG. 3—COMPLETE GAS FIRED BATH

Gas Control "V-V," Inspirators "I-I," Pressure Gauges "G-G,"
High Pressure Gas Line "H-H"

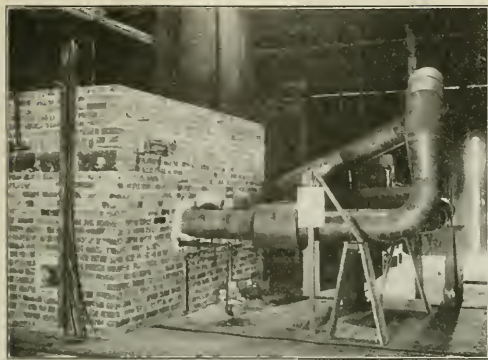


FIG. 1—TEMPORARY ARRANGEMENT FOR BURNING POWDERED COAL UNDER A 300 HP. BOILER AT WESTERN AVENUE STATION

200 mesh screen and 95 per cent through a 100 mesh screen if the best results are to be obtained. It should then be fed directly to the furnace or if transportation or storage is necessary it should be kept air tight so far as possible to prevent absorption of moisture. The danger from explosion when handling this material is eliminated, if it is kept in bulk and not allowed to become suspended in a mixture of air. In the latter case a highly explosive atmosphere may be found which will readily ignite if brought in contact with a flame.

"The method of experiment and results of test made by this company are as follows:

"The coal is dried and pulverized by the Pacific Coast Coal Company, at their briquetting plant, near Renton, which is equipped with a Raymond pulverizing plant. It is then loaded in a special car equipped for the purpose, which consists of a box car in which is constructed a metal-lined hopper. The car is spotted at the steam plant over a chute which is connected to the car by a flexible hose and which feeds a small conveyor encased in a metal housing. The coal is elevated and dumped into a bunker, adjoining the power plant, from the bottom of which it is fed by means of two motor-driven screws into the supply pipe. The coal is then blown through the pipe a distance of 30 ft. to the front of the furnace, where it feeds into specially constructed burners, made of sheet iron, as shown in the accompanying photograph. The air supply to each burner is furnished by a motor driven blower with dampers installed to control the supply. The boiler has been equipped with an extended oven, as shown in picture, in order to furnish sufficient space for the proper ignition and combustion of the fuel. The following is a record of a test on the equipment run continuously for 12.8 hours, the duration of the test being determined by the limited facilities for storage and handling of the fuel. The coal was weighed in the car as delivered to the plant and the net weight determined by a subsequent weight of the car after unloading. The test was run until all coal was consumed. The water was measured by a Venturi water meter installed in an individual feed line to the boiler and all instruments were checked for accuracy before starting. The test was made on a 300 hp. B. & W. boiler on March 23, 1917. The coal analysis is as follows: Moisture, 5.4; Volatile, 37.2; Fixed Carb., 47; Ash, 10.4; Sulp., 0.56; B.T.U., 11,760.

The ash analysis is as follows: SiO_2 , 44; FeO , 10.45; Al_2O_3 , 32.88; CaO , 7.75; MgO , 2.40. The screen

test gave 5.8 per cent on 100 mesh; 34.6 per cent through 100 on 200 and 59.6 per cent through 200.

RESULTS OF TEST

Duration of test.....	12.8 hrs.
Average boiler hp. developed.....	357
Total water evaporated.....	143,231 lb.
Average temperature of feed water.....	185 deg. F.
Average steam pressure.....	106.5 lb. gauge
Average temperature of steam.....	399 deg. F.
Average flue gas temperature.....	528 deg. F.
Average draft at uptake.....	0.17 in. water
Average flue gas analysis.....	CO_2 , 17 per cent; oxygen, 2 per cent; CO , 0 per cent
Total coal burned.....	18,539 lb.
Actual evaporation per lb. of coal.....	7.8 lb.
Equivalent evaporation from and at 212 deg.....	8.6 lb.
Boiler efficiency.....	71 per cent

"It was noted during the test that the boiler could be forced to 200 per cent of rating without any apparent damage to brick setting or tubes. The stack was perfectly clear under these conditions, and there was no fusing of the ash. About one-third of the latter was found deposited in the second and third passes of the boiler.

"The results of the experiment tend to refute most of the adverse criticism of this method of burning coal. There was no formation of slag in the furnace or on the tubes; there was no shower of cinders and ashes emitted from the smoke stack and there was no damage done the boiler from heavy overload under these conditions.

"From our experiments in burning these various fuels we find that (assuming pea coal at \$1.60 per gross ton) the relative prices of the fuels at which they would have equivalent heating values are as follows:

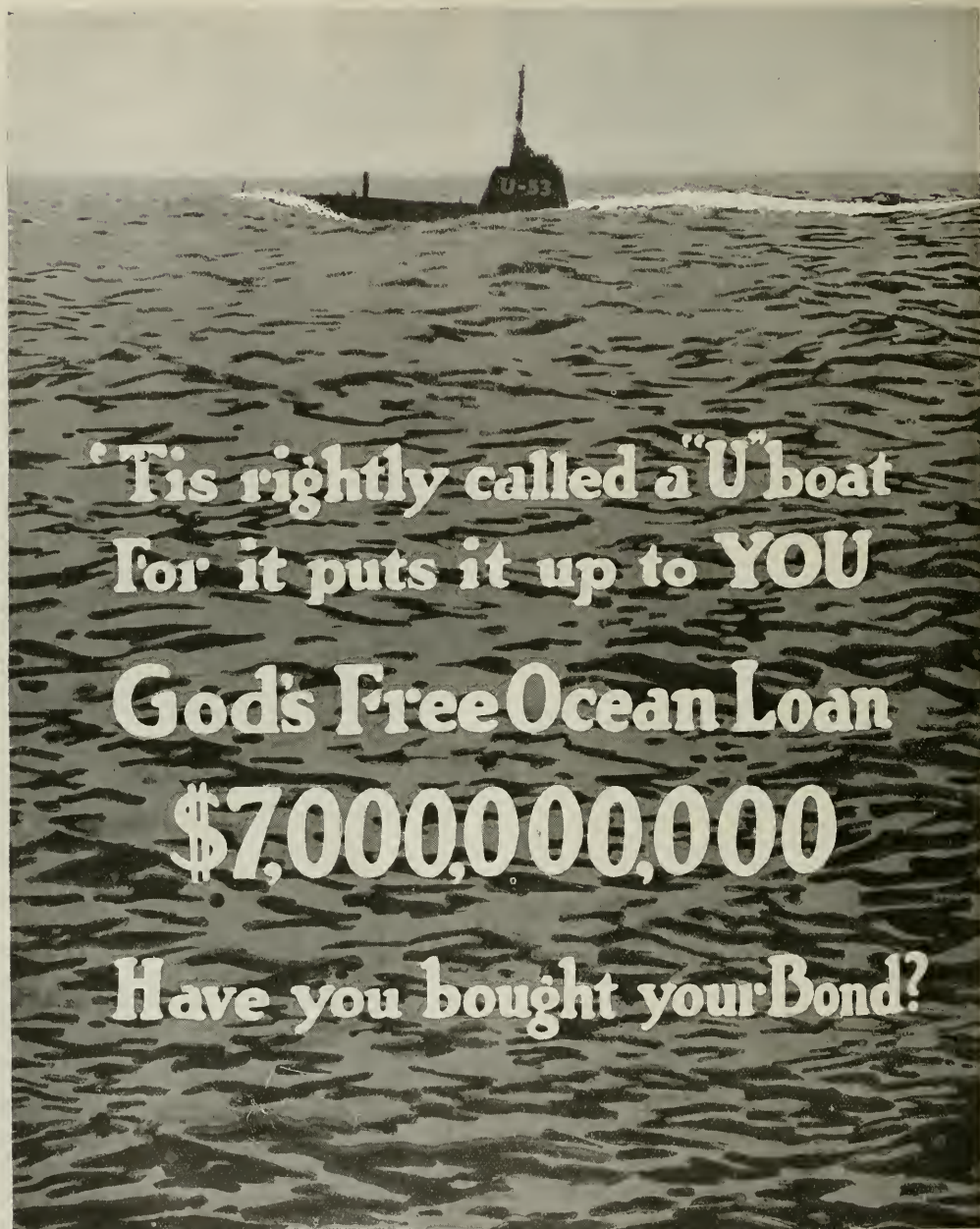
Pea coal on chain grates, at \$1.60 per gross ton, delivered.
Fuel oil, at 56 cents per barrel, delivered.
Powdered coal, at \$2.20 per gross ton, delivered.

"That the powdered coal can be burned without physical difficulty is practically assured, and the question now to be determined is, "At what price can powdered coal be procured?" If the coal can be dried and pulverized at a cost of 35 cents per gross ton, including overhead charges on the investment which is the figure submitted by some manufacturers, the question depends upon the price which must be paid the mines for their product.

"If, by our experiments we are able to prove the feasibility and economy of burning our lignite coals in powdered form, there will undoubtedly be created a large market for it both in stationary and marine practice. A lively interest is being taken in our work by all large consumers and producers of fuel in this territory, as well as by the University of Washington and the Government Bureau of Mines who have offered and rendered all assistance possible. We hope that within a few months the success of our efforts will have been finally demonstrated and that we may be the means of introducing the practice of burning powdered coal under stationary and marine boilers in the Pacific Northwest.

Osmotic Pressure Discussed by Faraday Society.—

A general discussion on "Osmotic Pressure" was held on Tuesday, May 1, 1917, by the Faraday Society in London. Sir Oliver Lodge, F.R.S., presided over the discussion, which was opened by Prof. Alfred W. Porter. Dr. F. Tinker read a paper on "The Colloidal Membrane: Its Properties and Its Function in the Osmotic System." Mr. W. R. Bousfield, F.R.S., read a paper on "Osmotic Pressure in Relation to the Constitution of Water and the Hydrates of the Solute."



THE LIBERTY LOAN

The above poster was designed by the Art Department of the McGraw-Hill Publishing Co., Inc.

The first issue of the "liberty loan" will be \$2,000,000,000. Secretary McAdoo has announced that subscriptions will be received until June 15. The bonds, which will bear $3\frac{1}{2}$ per cent interest, will be issued in denominations as low as \$100. A committee of leading American bankers headed by Benjamin Strong, Jr., has been formed to assist the government in the distribution of the loan and a nation-wide advertising campaign is being planned. Subscriptions have been pouring in at a rapid rate from all parts of the country, and inquiries have swamped the banking institutions.

Have you bought your bond?

Personal

Mr. G. A. Burrell, consulting chemical engineer of Pittsburgh, Pa., and for eight years in charge of gas investigations of the Bureau of Mines, has been selected by Mr. Van H. Manning, director of the Bureau of Mines, to take charge of research work on matters pertaining to gas warfare. Mr. Manning is chairman of a committee of the National Research Council. The latter is a branch of the Council of National Defense.

Mr. W. C. Dumas, for eight years past a member of the firm of A. M. Lloyd Laboratory of Atlanta, Ga., has sold his interests to Mr. A. M. Lloyd. He has been appointed as State Chemist of Georgia by the new Commissioner of Agriculture, Mr. J. J. Brown. Mr. Dumas began his new work on May 1.

Mr. F. N. Flynn, general superintendent of the Chile Exploration Company at Chuquicamata, Chile, has severed his connections with that company and was expected to arrive in New York the latter part of April.

Professor C. R. Richards, professor of mechanical engineering and head of the department since 1911, has been appointed dean of the College of Engineering and director of the Engineering Experiment Station of the University of Illinois to succeed Dr. W. F. M. Goss, who has resigned to become president of the Railway Car Manufacturers' Association of New York.

Professors Robert E. Rose and Harlan L. Trumbull of the University of Washington will spend one year of research study on the tanning of leather and phases of physical chemistry at the Mellon Institute of Industrial Research in Pittsburgh, Pa. Both will start their studies about June 1.

Professor Albert Sauveur, professor of metallurgy and metallography of Harvard University, has been given leave of absence for the first half of 1917-18.

Mr. C. H. Todd of Youngstown, Ohio, has resigned the presidency of the Standard Steel & Construction Company, which he recently organized. He will be succeeded by E. C. Miller of Philadelphia. Mr. Todd was president of the Petroleum Iron Works, Petroleum, Pa., for many years.

Mr. G. H. Upington has been appointed manager of the recently opened New York office of the Braemar Air Conditioning Corporation of 90 West Street, New York.

Mr. Charles S. Vought has been appointed assistant general manager of sales of the American Steel Export Co., Woolworth Building, New York. Mr. Vought was formerly one of the managers of the order department of the Cambria Steel Co.

Dr. M. C. Whitaker, head of the department of chemical engineering, Columbia University, was elected vice-president of the U. S. Industrial Alcohol Co., at the meeting of their board, on April 19. In this capacity Mr. Whitaker will serve as chairman of the manufacturing committee in charge of plants and operations, chairman of the research committee in charge of the new laboratories at Baltimore, and as a member of the sales committee of the company.

Obituary

Mr. Earle C. Bacon, well known in engineering, mining and machinery circles, died on Monday, April 9, at his country home in North Salem, N. Y., after a short illness. Mr. Bacon was born in Providence, R. I., in 1849, and had an active and honorable business career of nearly 50 years. He started his engineering course with the Delamater Iron Works of New York, N. Y.,

and, at the age of 21, formed a partnership with C. E. Copeland under the firm name of Copeland & Bacon. The firm was dissolved in 1893 and from 1894 until his death Mr. Bacon carried on the business under his own name, his business offices in the Havemeyer Building, New York City, being within a few hundred feet of his original location.

He was a pioneer in the development of hoisting engines and was an expert on the mining and milling of asbestos. He was one of the oldest members of the American Society of Mechanical Engineers, and was also a member of the Union League and Machinery clubs.

CURRENT MARKET REPORTS

The Iron and Steel Market

The volume of steel buying since the United States declared war has probably been greater than in the period preceding, but there is clearly a difference in the character of the buying, as there is more contracting by ordinary buyers, jobbers and manufacturing consumers, and still less buying of specific lots of material destined for certain construction work. As a matter of fact there is very little of the latter class of business now going through, in the form of orders for locomotives and cars, and bridges, buildings, etc.

A year or more ago the outstanding feature of the situation was that the orders on mill books represented specific undertakings, to the extent of an unusually high proportion, and this business would not be at all likely to be subject to cancellation or postponement in delivery. At the present time there is a great deal of specific business on books, but a much larger proportion of the total than formerly is in the form of requirement or open contracts, subject to specification in future. The amount of business on books is not as sure a criterion as formerly of the steel trade's prospects. It represents rather the expectations of buyers as to the future condition of their business, and their fears that if they did not place contracts they would be left without material.

MILLS OUT OF THE MARKET

The total volume of steel buying in the first half of May has been materially smaller than the rate in April, for the reason that many mills have withdrawn from the market. Three important subsidiaries of the Steel Corporation are out, the American Steel & Wire Company, the American Sheet & Tin Plate Company and the National Tube Company. The independents making the products thus represented are securing higher prices than those at which the Steel Corporation subsidiaries last sold. The wire company withdrew from the market early in April and later in the month the independents advanced wire products \$6 a ton, making nails \$3.50 a keg. The American Sheet & Tin Plate Company early in April announced its prices for second half contracts and before the end of the month its prospective tonnage was all sold. The independents then advanced prices, which are now fully a cent a pound higher than those at which the Steel Corporation subsidiary sold. In April the National Tube Company sold between one-third and one-half more than it shipped, though the sales were not as heavy as those of March. At the beginning of May the independents advanced their prices on pipe six points or nearly \$12 a ton and the National Tube Company concluded not to follow the advance, so that it was forced to withdraw from the market, its regular trade being well covered. The independents are getting more out of the situation than the Steel Corporation, as regards

prices, but when the movement is over the Steel Corporation's relations with its customers will be better than will obtain in the case of some of the independents.

STEEL EARNINGS

The Steel Corporation's earnings will be very comfortable nevertheless. Its earnings in March were \$43,630,422, with shipments at several per cent less than capacity, and invoice prices an average of perhaps \$20 a ton less than prices at which recent sales have been made. The Corporation seems to be in line to earn considerably more than \$60,000,000 in some future month.

GOVERNMENT BUYING

The United States Government's steel requirements are estimated at about 1,100,000 tons, according to the present program, of which fully 600,000 tons has already been placed, chiefly in connection with the 1917 naval program. The prices are all at very material concessions from existing market prices for far forward delivery, though much of the material is wanted for very early shipment. The Government has now become purchasing agent for the European Allies, succeeding Messrs. J. P. Morgan & Company, and the Advisory Commission of the Council of National Defense has been considering the question of what prices the Government should propose that the steel manufacturers should accept for steel for the European governments. The law relating to purchases for the Government does not seem to apply to the case of the Government acting as purchasing agent, but the steel mills are in mood to make very material concessions.

With 1,100,000 tons of steel required by the United States Government, and probably a larger tonnage to be bought for its Allies, chiefly shell steel, the war requirements do not seem to mount to very high proportions, seeing that the country is making more than 2,500,000 tons of finished rolled steel a month. In the mobilizing of various industries for prosecution of the war, however, a great deal of steel will indirectly be used. To produce larger crop yields and to take care of the additional planting that is being done the agricultural implement makers anticipate a heavier demand for their products. More steel will probably be called for on account of the railroads, and thus there is likely to be a demand for steel all along the line. While the steel can be classed as steel required on account of the war it may not represent a corresponding increase in the total demand, for the reason that there will be some diminution in the consumption of steel for strictly peace purposes. The extent to which the country's industrial activities will be modified cannot of course be gaged at this early date.

The tin plate situation is receiving careful consideration and production is to be speeded up as much as possible. Fear of a scarcity of tin plate does not arise from production being curtailed, but from the requirements having become altogether abnormal. In 1916 the production of tin plate was about 1,350,000 gross tons, or 300,000 tons beyond the previous record, yet at the present time production is at a rate about 20 per cent greater than the average rate in 1916.

THE PHYSICAL CONDITION

The iron and steel industry has experienced a practically complete recovery from the restriction of output that was forced during the winter by the traffic congestion. Car supplies in the Connellsville coke region are much below the regular allotments, but on account of so many by-product plants having been completed lately the Connellsville shipments are practically adequate. Some of the newer by-product plants have had

surplus output lately and have been selling by-product coke in prompt lots. Pig iron production is at a rate slightly exceeding 41,000,000 tons a year, against 39,434,797 tons produced last year, and three or four additional furnaces are to be completed within a few months. The only new furnace thus far this year is Gary No. 4 blown in April 14.

Lake Superior ore shipments in April amounted to only 211,532 tons, no shipments being made from the head of the lakes, on account of ice. This is a loss of about 1,500,000 tons as compared with last year, and May shipments will probably be short as much more, so that on account of the cold spring the lake shipping season starts handicapped by about 3,000,000 tons, but this can probably be made up.

The steel works are fully supplied with pig iron, but steel making capacity increases more rapidly than blast furnace capacity, and the pinch in future may be in pig iron rather than steel. Pig iron has been advancing steadily in all markets, and is now at an average of \$40 a ton at furnace, a trifle more than three times the low level of two years ago, while billets have quadrupled and finished steel has somewhat more than tripled in price.

With centralized control of the railroads it is expected that serious congestion will be avoided in future and the iron and steel industry will probably be able to operate at capacity. The adoption of the selective draft has improved the outlook as to the supply of labor.

The Non-Ferrous Metal Market

Monday, May 7.—The metal markets have been undergoing a period of uncertainty regarding the prices which should be asked. However, no important changes have been noted, especially as to lower prices. Copper remains the same, spelter is slightly lower, lead is higher in a strong market and tin is also higher.

Copper.—There is very little spot copper available except some resale lots which are held at from 31 to 32 cents. July copper, which is also scarce, is quoted at 30 to 30½ cents. Third quarter is held at 27½ to 28½ cents and fourth quarter at 26½. This applies to both electrolytic and lake. Copper production is being speeded up and is expected to run considerably ahead of last year.

Tin.—Tin is higher and has advanced to 58.50 to 58.75 for prompt Straits. Sales have been light recently owing to the small spot stocks on hand. The arrivals in April were only 4393 tons, and future arrivals are of course uncertain. The government has taken steps to find substitutes for tin cans in packing many articles. Little interest is shown in futures at the present time.

Lead.—The trust price of lead has been advanced to 9.50 cents New York. The lead market is very strong and independents are asking up to 10.50 cents for prompt shipment, with a scarcity of supplies still prevailing.

Large producers and consumers are holding off pending a definite understanding as to the Government's requirements and the price to be paid.

Spelter.—Consumers continue to show no desire to purchase large supplies and spelter is now down to 9.25 to 9.50 cents at New York for May and June shipment. Fourth quarter can be had at 9.00 to 9.12½ cents.

Other Metals.—There is very little demand for spot antimony, which continues at 31.00 to 32.00 cents. Aluminium is unchanged at about 60.00 cents. Magnesium is unchanged at \$2.50-\$3.00, quicksilver is \$113.00 per flask, platinum (pure) is \$105.00 per ounce, and silver 74¾ cents. Tungsten concentrates are \$20.00 per unit for 60 per cent ore.

Chemical Market

Coal Tar Products.—There has been a very active movement in practically every item under this classification during the past fortnight and higher levels are recorded. The tendency upon the part of holders of stocks appears to be a hesitating one and they feel that by restricting offers and holding for later developments they will benefit materially.

Benzol.—While spot values have not undergone change, the position of future deliveries has stiffened up materially and forward deliveries are now being made on the basis of spot prices. But comparatively few offerings of important quantities are being made in any position. Spot lots have been reaching the market in amounts that have rarely involved more than a car and these have generally been taken up quickly by consumers who believe that at present spot prices benzol is a good buy.

Toluol.—The situation in toluol is extremely firm, and interesting developments are expected. It has been rumored that the leading producers are accepting contracts with the proviso that they will be filled providing the government does not make demands for material. However, this has been denied in certain important quarters. There seems to be but little doubt that large orders of *T N T* will materialize and that these orders will remove large quantities of toluol from regular consuming channels.

Aniline Oil.—Following out predictions made in these columns some time ago, the recent movement in aniline oil, and prices realized, have been gratifying from a producers' viewpoint. Aniline oil is considered one of the real good purchases that can be made at the moment. It is known that certain large interests have purchased any desirable quantities that have recently reached the open market as a matter of investment rather than consumption. Plants that abandoned the manufacture of the product some time ago when the market touched the 20c. level are again preparing to turn out the product, and oil now produced containing 2 or 3 per cent impurities is being further refined and offered in the open market.

Phenol.—The general undertone has exhibited much firmness during the interval but there has so far been no actual improvement in prices. Competition is quite keen and producing factors appear reluctant to disturb present conditions.

Ammonium picrate.—The purchase of 430 tons of ammonium picrate by the government and the possibility of further orders has created more confidence in the situation. The order for *ammonium picrate* went to one of the large explosive manufacturers at a price much below those submitted by other bidders. This firm also secured the recent contract on *T. N. T.* at a much lower price than quoted by competitors and it seems apparent that this firm is anxious for government business.

Dimethylaniline, dinitrochlorbenzol and dinitrobenzol have all been subject to slight advances as a result of more demand.

Beta Naphthylamine.—A commercial production of this product is announced for the first time. The price named on contract for technical is \$2.50 and \$3.50 for refined.

Naphthaline.—Flakes and balls have been in urgent demand with prices established on a higher level. Offerings continue restricted.

Alpha Naphthylamine.—Keen competition and a larger production has resulted in a break in values. Business, especially for export, has been done on a low level. Present values are at the lowest point that has

prevailed since the product was manufactured in this country.

Heavy Chemicals.—A brisk general movement has been noted in practically all items under this classification despite the difficulty of securing shipbottoms for export.

Nitrite of Soda.—A spectacular movement has been noted in this product and large buyers have paid as high as 36c. Several firms are planning productions and a New York firm announces that beginning June, fifty tons monthly will be available. However, this material will be marketed at the highest price that can be obtained and there does not appear to be much hope for lower prices for some time to come.

Bichromates.—The sodium product has sold as low as 13c. and as the leading producers established the price of 24c. last fall and sold possibly three-quarters of their production, those who are making deliveries of the product at 24c. with the market at 13c. are shedding crocodile tears. The market has been subject to much manipulation and speculation and consumers have therefore suffered accordingly. During the past few days there has been a turn for the better and somewhat higher prices would not be surprising.

Cyanides.—A very weak market prevails as a result of the dumping of large quantities of English and Japanese cyanides on this market. Large holders who bought on speculation have been caught and heavy losses have resulted.

Caustic Soda.—For the first time in a lengthy period this product has sold above 5½c. for nearby delivery. This shows an increase of 2½ to 30 per cent within the past few weeks. Practically all producers are sold out. The situation is extremely firm. *Soda ash* has followed the caustic market somewhat but owing to packing in bags the export movement has been restricted.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET MAY 5, 1917			
Acetic anhydride	lb.	\$1.50	— \$1.75
Acetone, drums	lb.	.27	— .27½
Acid, acetic, 28 per cent.	lb.	.04½	— .05
Acetic, 56 per cent.	lb.	.09½	— .10
Acetic, glacial, 99½ per cent, carboys	lb.	.27	— .30
Boric, crystals	lb.	.11	— .12
Citric, crystals	lb.	.72	— .74
Hydrochloric, commercial, 18 deg.	lb.	.01½	— .01½
Hydrochloric, 20 deg.	lb.	.01½	— .01½
Hydrochloric, 25 conc, 28 deg.	lb.	.01½	— .01½
Hydrofluoric, 30 per cent, in barrels	lb.	.04½	— .05
Lactic, 44 per cent.	lb.	.11½	— .12
Lactic, 22 per cent.	lb.	.04½	— .05
Nitric, 36 deg.	lb.	.05½	— .05½
Nitric, 42 deg.	lb.	.06½	— .07
Oxalic, crystals	lb.	.45	— .46
Phosphoric, 50 per cent.	lb.	.07	— .08
Picric	lb.	.65	— .70
Pyrogallic, resublimed	lb.	3.50	— 4.00
Sulphuric, 60 deg. Brimstone	ton	19.50	— 21.00
Sulphuric, 66 deg.	ton	29.00	— 30.00
Sulphuric, oleum (Fuming), tank cars	ton	38.00	— 42.00
Tannic, U. S. P., bulk	lb.	.45	— .50
Tartaric, crystals	lb.	.79	— .80
Alcohol, grain, 158 proof	gal.	3.05	— 3.07
Alcohol, wood, 95 per cent.	gal.	1.00	— 1.02
Alcohol, denatured, 180 proof	gal.	.70	— .72
Alum, ammonia lump	lb.	.04	— .04½
Alum, chrome ammonium	lb.	.17½	— .18
Alum, chrome potassium	lb.	.40	— .45
Alum, chrome sodium	lb.	.12½	— .13
Alum, potash lump	lb.	.05½	— .06
Aluminium sulphate, technical	lb.	.01½	— .02
Ammonium sulphate, iron free	lb.	.03½	— .03½
Ammonia aqua, 26 deg. carboys	lb.	.06	— .06
Ammonium carbonate	lb.	.13	— .14
Ammonium nitrate	lb.	.16½	— .17
Ammonium, sulphate domestic	lb.	.05½	— .05½
Anil acetate	gal.	4.00	— 4.25
Arsenic, white	lb.	16½	— 17½
Arsenic, red	lb.	.25	— .30
Barium chloride	ton	85.00	— 90.00
Barium chloride (Blanc Fixe), powder	lb.	.04	— .04½
Barium nitrate	lb.	.10½	— .11
Barium peroxide, basis 70 per cent.	lb.	.27	— .27½
Bleaching powder, 35 per cent chlorine	lb.	.03½	— .03½
Borax, drums	lb.	.08	— .08½
Borax, crystals, sacks	lb.	.08	— .08½
Brimstone, crude	ton	45.00	— 50.00
Bromine, technical	ton	3.00	— .30
Calcium, acetate, crude	lb.	.04½	— .04½
Calcium, carbide	ton	80.00	— 90.00
Calcium chloride, 70-75 per cent, fused, lump	ton	26.00	— 27.00

Calcium peroxide	lb.	1.80	—	1.90
Calcium phosphate	lb.	.30	—	.31
Carbon bisulphide	lb.	.04	—	.04½
Carbon tetrachloride, drums	lb.	.15	—	.16
Caustic potash, 88/92 per cent.	lb.	.56	—	.58
Caustic soda, 76 per cent, spot, New York	lb.			
Chlorine, liquid	lb.	5.65	—	5.85
Cobalt oxide	lb.	.15	—	.20
Copperas	100 lb.	1.55	—	1.60
Copper carbonate	lb.	1.00	—	1.10
Copper cyanide	lb.	.25	—	.24
Copper sulphate, 99 per cent, large crystals	lb.	.72	—	.75
Cream of tartar, crystals	lb.	.09½	—	.09½
Epsom salt, bags	100 lb.	.46½	—	.47
Formaldehyde, 40 per cent	lb.	3.00	—	3.25
Glauber's salt	100 lb.	.15¾	—	.16½
Glycerine, bulk, C. P.	lb.	.60	—	.65
Iodine, resublimed	lb.	.57	—	.57½
Iron oxide	lb.	3.50	—	3.60
Lead acetate, white crystals	lb.	.02	—	.08
Lead arsenate	lb.	.14½	—	.14½
Lead nitrate	lb.	.10½	—	.10½
Litharge, American	lb.	.16½	—	.17
Lithium carbonate	lb.	.18	—	.14
Manganese dioxide	lb.	1.02	—	1.05
Magnesium carbonate, tech.	lb.	.65	—	.66
Molybdic acid, basis 85 per cent.	lb.	.12	—	.14
Nickel salt, single	lb.	3.25	—	3.4½
Nickel salt, double	lb.	.11½	—	.11½
Phosphorus, red	lb.	.11	—	.12
Phosphorus, yellow	lb.	1.15	—	1.20
Potassium bicarbonate	lb.	1.15	—	1.20
Potassium bromide granular	lb.	.45	—	.45
Potassium carbonate calcined, 80-85 per cent	lb.	1.00	—	1.05
Potassium chlorate, crystals	lb.	.44	—	.52
Potassium cyanide, 98-99 per cent.	lb.	.57	—	.60
Potassium iodide	lb.	2.15	—	2.25
Potassium mullate 80-85 p. c. basis of 80 p. c. ton	375.00	—	—	390.00
Potassium nitrate	lb.	.29	—	.33
Potassium permanganate	lb.	.31	—	.33
Potassium prussiate, red	lb.	4.00	—	4.10
Potassium prussiate, yellow	lb.	2.00	—	2.00
Potassium sulphate, 90-95 p. c. basis 90 p. c. ton	285.00	—	—	300.00
Rochelle salts	lb.	.93	—	.94
Sal ammoniac, gran.	lb.	.37½	—	.38
Sal ammoniac, white gran.	lb.	.10	—	.12
Salt cake	100 lb.	.17	—	.18
Silver cyanide	oz.	1.05	—	1.10
Silver nitrate	oz.	.90	—	.95
Soda ash, 58 per cent, light, flat	100 lb.	.70	—	.75
Soda ash, 58 per cent, dense, flat	100 lb.	.47½	—	.48
Sodium acetate	lb.	3.25	—	3.35
Sodium benzoate	lb.	3.85	—	3.90
Sodium bicarbonate, domestic	100 lb.	.38	—	.39
Sodium bicarbonate, English	lb.	6.25	—	7.00
Sodium bichromate	lb.	1.95	—	2.00
Sodium bisulphate, powd.	lb.	.11	—	.11½
Sodium chlorate	lb.	.03½	—	.04
Sodium cyanide	lb.	.24½	—	.25½
Sodium fluoide, commercial	lb.	.20	—	.20
Sodium hypochlorite	lb.	.12½	—	.13½
Sodium nitrate, refined	lb.	.40	—	.42
Sodium nitrite	lb.	4.75	—	5.00
Sodium peroxide	lb.	.26	—	.32
Sodium phosphate (f.p.)	lb.	.50	—	.92
Sodium prussiate, yellow	lb.	.30½	—	.04¾
Sodium silicate, liquid	100 lb.	.30	—	.31
Sodium sulphide, 30 per cent crystals	lb.	2.35	—	2.50
Sodium sulphide, 60 per cent fused	lb.	.0150	—	.0155
Sodium sulphate	lb.	.0250	—	.0255
Strontium nitrate	lb.	.40	—	.43¼
Sulphur chloride, drums	lb.	.28	—	.30
Sulphur dioxide, liquid, in cylinders	lb.	.11	—	.12
Sulphur, flowers, sublimed	lb.	.11	—	.12
Sulphur, roll	100 lb.	3.20	—	3.30
Sulphur, crude	ton	2.60	—	2.70
Tin bichloride, 50 deg.	lb.	45.00	—	46.00
Tin oxide	lb.	.14½	—	.14¾
Tungstic acid	lb.	.03	—	.03
Zinc carbonate	lb.	1.10	—	1.50
Zinc chloride	lb.	.26	—	.27
Zinc cyanide	lb.	.15½	—	.16
Zinc dust	lb.	.50	—	.55
Zinc oxide, American process XX	lb.	.18	—	.19
Zinc sulphate	lb.	.12½	—	.12½
	lb.	.06¾	—	.07

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.57	—	.60
Benzol, 90 per cent	gal.	.57	—	.59
Toluol, pure, water white	gal.	1.85	—	2.00
Xylo, pure, water white	gal.	.55	—	.60
Solvent naphtha, water white	gal.	.17	—	.17½
Solvent naphtha, crude, heavy	gal.	.14	—	.15
Cresol oil, 25 per cent.	gal.	.30	—	.32
Dip oil, 20 per cent.	gal.	.24	—	.26
Pitch, various grades	ton	14.00	—	20.00
Carbolic acid, crude, 87 per cent.	lb.	.95	—	.98
Carbolic acid, crude, 50 per cent.	lb.	.32	—	.36
Carbolic acid, crude, 25 per cent.	lb.	.20	—	.32
Cresol U. S. P.	lb.	.20	—	.20

Intermediates, Etc.

Alpha naphthylamine	lb.	1.00	—	1.25
Aniline oil	lb.	.30	—	.31
Aniline salts	lb.	.33	—	.34
Anthracene, 80 per cent.	lb.	.10	—	.11
Benzaldehyde	lb.	4.00	—	4.50
Benzidine, base	lb.	1.80	—	1.90
Benzidine, sulphate	lb.	1.55	—	1.60
Benzol acid	lb.	6.50	—	8.00
Beta naphthol, sublimed	lb.	.85	—	.86
Beta naphthol, 90 per cent, American	lb.	2.50	—	2.55
Dichlor benzol	lb.	.23	—	.25
Dinitrochlorbenzol	lb.	.46	—	.48

Dimethylaniline	lb.	.58	—	.60
Diphenylamine	lb.	.80	—	.85
H-acid	lb.		—	Nominal
Metaphenylenediamine	lb.	1.50	—	1.75
Monochlorbenzol	lb.	.30	—	.32
Naphthalene, flake	lb.	.08½	—	.09¾
Naphthionic acid, crude	lb.	1.50	—	1.75
Nitro naphthalin	lb.	.55	—	.60
Ortho-aminophenol	lb.		—	
Ortho-toluidine	lb.	1.20	—	1.60
Para-aminophenol, base	lb.	.75	—	5.60
Paratoluidine	lb.	1.15	—	1.20
Paraphenylenediamine	lb.	3.50	—	4.00
Para toluidine	lb.	2.20	—	2.30
Phenol, U. S. P.	lb.		—	.45
Resorcin, technical	lb.	9.00	—	17.00
Resorcin, pure	lb.	16.00	—	17.00
Salicylic acid	lb.	.87½	—	.90
Salol	lb.	1.75	—	2.00
Sulphanilic acid	lb.	.73	—	.33
Tolidin	lb.	3.00	—	
Toluidine-mixture	lb.	.65	—	.70

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	3.10	—	...
Corning, Ohio	bbl.	2.40	—	...
Somerset, Ky.	bbl.	2.20	—	...
Wooster, Ohio	bbl.	2.18	—	...
Indiana	bbl.	1.78	—	...
Illinois	bbl.	1.92	—	...
Oklahoma and Kansas	bbl.	1.70	—	...
Caddo, La., light	bbl.	1.90	—	...
Corsicana, Tex., light	bbl.	1.70	—	...
California	bbl.	.73	—	.82
Gulf Coast	bbl.	1.00	—	...

Lubricants

Black reduced, 29 gravity, 25-30 cold test	gal.	.13½	—	.14
Cylinder, light	gal.	.2	—	.26
Cylinder, dark	gal.	.18	—	.19
Paraffine, high viscosity	gal.	.29½	—	.30
Paraffine, 903 sp. gr.	gal.	.21½	—	.22
Paraffine, .865 sp. gr.	gal.	.18½	—	.19

Flotation Oils

(Prices at New York)

Pine oil, steam distilled, sp. gr. 0.925-0.940	gal.	.52½	—	...
Pine oil, destructively distilled, sp. gr. 0.920-0.940	gal.	.48	—	...
Pine-tar oil, crude, sp. gr. 0.925-1.005	gal.	.32	—	...
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	.23	—	...
Pine oil, light, sp. gr. 0.950, tank cars	gal.	.37	—	...
Pine oil, heavy, sp. gr. 1.025, tank cars	gal.	.40	—	...
Pine oil, thin, sp. gr. 1.060-1.080	gal.	.31	—	...
Turpentine, crude, sp. gr. 0.980-1.000	gal.	.19	—	...
Hardwood oil, sp. gr. 0.960-0.990	gal.	.21	—	...
Hardwood oil, sp. gr. 1.06-1.08	gal.	.23	—	...

Vegetable and Other Oils

China wood oil	lb.	.14½	—	.15
Cottonseed oil, crude	gal.	1.08	—	...
Linseed oil, raw, cars	gal.	1.24	—	...
Peanut oil, crude	gal.	1.15	—	...
Rosin oil, first run	gal.	.38	—	...
Rosin oil, fourth run	gal.	.67	—	...
Soya bean oil, Manchuria	lb.	.14½	—	...
Turpentine, spirits	gal.	.50	—	...

Miscellaneous Materials

Barytes, floated, white, foreign	ton	38.00	—	40.00
Barytes, floated, white, domestic	ton	28.00	—	32.00
Beeswax, white, pure	lb.	.55	—	.60
Carnauba wax, highest grade	lb.	.51	—	.53
Caseln	lb.	.19	—	.23
Chalk, light, precipitated, English	ton	8.00	—	12.00
Feldspar	ton	.80	—	1.05
Fuller's earth, powdered	100 lb.	.80	—	1.05
Ozokerite, crude, brown	lb.	.60	—	.70
Ozokerite, American	lb.	.35	—	.35
Red lead, dry, carloads	lb.	1.13½	—	...
Rosin, 280 lb.	bbl.	6.20	—	...
Soapstone	ton	10.00	—	12.50
Talc, American, white	ton	10.00	—	13.00
White lead, dry	lb.	.09½	—	...

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	Nominal	—	...
Chrome cement, Grecian	net ton	60.00	—	...
Clay brick 1st quality fireclay	per 1000	45.00	—	...
Clay brick, second quality	per 1000	30.00	—	...
Magnesite, Grecian, dead burned	net ton	90.00	—	...
Magnesia brick, Grecian, 9x4½x2½	net ton	140.00	—	...
Silica brick	per 1000	45.00	—	...

Ferroalloys

Ferrochromium	lb.	Nominal	—	...
Ferromanganese, domestic, delivered	ton	400.00	—	425.00
Ferromanganese, English	ton	200.00	—	...
Ferromolybdenum, per lb. of Mo.	lb.	4.25	—	...
Ferrosilicon, 50 per cent, carloads, del. Pitts-	ton	240.00	—	250.00
Ferrosilicon, 50 per cent, contract	ton	100.00	—	...
Ferrotungsten, 75-85 per cent, f.o.b. Pitts-	ton	45.00	—	...
— burgh	lb.	2.00	—	...
Ferrovanadium, f.o.b. works	lb.	3.25	—	3.50

INDUSTRIAL

Financial, Construction and Manufacturers' News

Financial

New Companies

Alaskan Copper River Mining Company, Everett, Wash., incorporated for \$2,000,000 by E. B. McGill, T. M. Williams and Dr. C. A. Mead, to develop gold mines in Alaska.

American Fire Extinguisher Company, Pittsburgh, Pa., has been incorporated with a capital of \$50,000 to manufacture chemicals, fire extinguishers of all kinds. The incorporators are W. A. McCoy, Pittsburgh, Pa., W. I. Lofland, Geo. W. Morgan, of Dover.

The American Ore Reduction Company, New York City, has been incorporated in Delaware with a capital of \$5,000,000, to manufacture machinery for metallurgical operations. The incorporators are Roger A. Fryor, Jr., William l'Huillier, George B. Hayes, John C. O'Brien and Major T. J. Whelan, of New York City.

Antwerp Naval Stores Company, Manhattan, has been incorporated with a capital of \$10,000 to act as selling agents in naval stores. The incorporators are Walter Cook, Jr., Ralph R. Maiden, Jose Ge. Desne.

Becker, Pennrich & Co., Inc., New York, has been incorporated with a capital of \$20,000 to deal in chemicals, dyes, medicines. The incorporators are H. C. Becker, H. C. Pennrich, E. Brophy, 82 Beatty Street.

The British-American Copper Mining & Smelting Company of Seattle, Wash., has been incorporated with a capital of \$2,000,000. Will develop copper properties in British Columbia. The incorporators are Arthur Bernstein, Norman Herman, Adam Beeler, John J. Sullivan, E. M. Kennard. Temporary offices, 510 White Building, Seattle.

The Capital City Iron & Metal Company, Bismarck, N. D., has been incorporated with a capital of \$15,000.

Central Oil Transportation & Development Corporation, Delaware, has been incorporated with a capital of \$5,000,000 to purchase oil lands and produce oil and natural gas and market the same. The incorporators are Samuel B. Howard, Louis H. Gunther, Geo. V. Reilly, all of New York.

Cherokee Mining Company, Wilbur, Wash., incorporated for \$100,000 to develop Cherokee group of claims. Incorporators are William Rakestraw, M. E. Bennett, Lloyd Harris, C. G. Edwards, all of Wilbur, and L. E. Spoker.

The Coastal Plain Oil Company, Cleveland, Ohio, has been incorporated with a capital of \$50,000. Headquarters, Houston, Texas.

The Coeur d'Alene Empire Mining & Milling Company, Spokane, Wash., incorporated to take over property of Coeur d'Alene Mining & Milling Company. Directors are H. W. Greenberg, T. H. Holland, F. D. Garrett, Frank Johnson and A. Herman, all of Spokane.

The Colfab Manufacturing Company, Philadelphia, Pa., has been incorporated with a capital of \$10,000, to manufacture chemicals and chemical compounds. K. G. Bird, Philadelphia, is the principal incorporator.

Dilworth Oil & Refining Company, Newkirk, Okla., has been incorporated with a capital of \$1,000,000. The incorporators are J. R. Uterback and W. A. Doty, Newkirk; M. R. Diggs, Chicago.

The Duplex Mfg. & Foundry Company, Elyria, Ohio, has been incorporated with a capital of \$50,000. The incorporators are M. A. Copeland, C. A. Alexander, Geo. A. Mowery, C. Verbsky and O. E. Schultz.

William F. Elissing & Co., New York City, has been incorporated with a capital of \$200,000 to deal in chemicals, liquids or solids. The incorporators are L. D. Della, D. F. Bodger, Morte S. Joseph, 299 Broadway.

Empire Smelting & Refining Company, Wilmington, Del., has been incorporated with a capital of \$100,000 to operate mills pertaining to the refining, mining and milling of metallurgical industries. The incorporators are Herbert E. Gatter, C. L. Rimlinger, Clement M. Egner, Wilmington, Del.

Engineering Sales Company, New York, has been incorporated with a capital of

\$10,000 to deal in metals. The incorporators are J. T. Abeles, W. P. Riley, 2 Rector Street.

The Federal Aniline Corporation, New York, has been incorporated with a capital of \$10,000 to manufacture and deal in dyes and chemicals. The incorporators are Richard Pick, Doris Lefkowitz, Arnold Blank.

The Great Eastern Oil & Gas Company, Aurora, Ind., has been incorporated with a capital of \$100,000 to develop oil and gas lands and to market the product of the same. The incorporators are Louis Bloom, H. C. Williams, Aurora, Ind.; E. W. Crisler, J. M. Horless, Gulfport, Miss.; W. H. Pilarz, Belfast.

Great Western Oil & Chemical Company, Oklahoma City, Okla., has been incorporated with a capital of \$2,000,000 to deal in oil and minerals of all kinds and to develop the same. The incorporators are R. H. Locke, A. J. McMahon, J. B. Dudley, all of Oklahoma.

The J. L. Hoffman Company, Allentown, Pa., has been incorporated with a capital of \$50,000 to manufacture chemicals. James L. Hoffman is president.

The Hudson Metal Manufacturing Company, 141 Railroad Avenue, Jersey City, N. J., has been incorporated with capital of \$25,000 to manufacture metal specialties. F. Ricciardelli, A. Salstrom and S. Schnabak, of Jersey City, are the incorporators.

The International Chemical Company of Seattle has been incorporated with a capital of \$15,000. Will deal in salt cake, anhydrous soda sulphate, glauber's salts, silicate of soda, sulphate of potash, narselguhe, etc. Incorporators are F. D. Donaldson, H. B. Brown, Alex. Neven, Day Karr, G. W. Gregory.

Itasca Oil & Gas Company, Inc., has been incorporated with a capital of \$100,000 to deal in petroleum, oil, natural gas, coal, iron. The incorporators are A. H. Squier, S. B. Squier and Clarence C. Squier.

Jersey Steel Company, Jersey City, N. J., has been incorporated with a capital of \$125,000 to manufacture steel ingots and billets by improved methods. The incorporators are A. B. Shanahan, W. Turner, H. Cross, Jersey City.

Kansas City Progress Oil & Refining Company, Independence, Kan., has been incorporated with a capital of \$1,000,000. The incorporators are Jas. R. Smith, H. W. Hones, Independence, Kan.; Merle V. Cadman, Tulsa, Okla.

The Liberty Steel Company of Warren, Ohio, has been incorporated with a capital of \$40,000 to deal in iron and steel. The incorporators are Edward E. Clark, R. A. Kenworth, Jr., Harold Taylor, John W. Ford and Leroy A. Manchester.

McCoy Machine Glass Company, Huntington, Va., has been incorporated with a capital of \$40,000 to deal in window glass. The incorporators are H. E. Camp, M. L. Camp, F. F. Rigall, P. P. Gibson and F. Mearns, Huntington, W. Va.

Frederick G. Marquardt, Inc., New York, has been incorporated with a capital of \$25,000 to manufacture paper, paper stock, etc.

Midgley & Prentice, Inc., Worcester, Mass., has been incorporated with a capital of \$25,000 to deal in iron and steel. The incorporators are F. Midgley, New York; treasurer, Robert L. Prentice, Worcester; clerk, Edna R. West, Worcester.

National Motor Power Company, Inc., Dover, Del., has been incorporated with capital of \$5,000,000 to manufacture chemicals and to deal in druggists' supplies of all kinds. The incorporators are Mark S. Cole, Mary S. Pollock, all of Dover, Del., incorporators.

New Jersey Products Company, West Orange, N. J., has been incorporated with a capital of \$500,000 to manufacture chemicals, glues, veneers, stains and shellac, paper products, phonographs, sound records and storage batteries, etc. The incorporators are Thomas A. Edison, Charles Edison, R. H. Allen, East Orange, N. J.; Stephen B. Mamhart, East Orange, N. J.; and A. C. Emery, Montclair, N. J.

Noonday Mines Company, Spokane, Wash., has increased its capital stock from \$250,000 to \$750,000, and purchased new group of claims. Extensions of operations planned.

The Northern Iron & Oil Company, Minneapolis, Minn., has been incorporated

with a capital of \$50,000. Headquarters, San Antonio, Texas.

Numbers Mining Company, Wilmington, Del., has been incorporated with a capital of \$1,000,000 for discovery and location of gold, silver, zinc, etc.

Oilmist Corporation, Wilmington, Del., has been incorporated with a capital of \$1,000,000 to prospect for oil and natural gas and market same. The incorporators are Harry W. Davis, M. L. Gatchell, L. A. Irwin, all of Wilmington.

Ozonol Chemical Corporation, Wilmington, Del., has been incorporated with a capital of \$1,000,000 to manufacture drugs, medicines, chemicals. The incorporators are Herbert E. Latter, C. L. Rimlinger and Clement M. Egner, Wilmington.

The Peerless Color Company, Inc., Bridge-water Township, N. J., has been incorporated with a capital of \$500,000 to manufacture colors and chemicals.

Pioneer Color Works, Inc., Brooklyn, N. Y., has been incorporated with a capital of \$10,000 to deal in colors and dyestuffs. The incorporators are J. Zobel, C. L. J. Svindler, 23 East Thirteenth Street.

Ramberg Iron Works, New York, has been incorporated with a capital of \$1,500,000 to manufacture steel and copper. The incorporators are Thos. W. Ramberg, Edward J. Widness, Rodney T. Martinsen.

The St. Nicholas Zinc Extension Company, Dover, Del., has been incorporated with a capital of \$1,000,000 to manufacture zinc, brass, etc. The incorporators are F. D. Buck, George W. Dillman and M. L. Harty, of Wilmington.

Sardou, Inc., New York, has been incorporated with a capital of \$25,000 to manufacture perfumes, soaps, toilet preparations. The incorporators are A. Keyrouse, B. C. Elliott, G. Sardou, 172 West 109th Street.

The Southern Oxygen Company, Austin, Texas, has been incorporated with a capital of \$20,000. The incorporators are F. H. Perry, D. C. Reed, F. G. Smith, O. H. Milliken and J. B. Robertson.

Superior Refining Process Company, San Francisco, Calif., has been incorporated with a capital of \$10,000. The incorporators are H. M. Curdy, H. E. Casey and M. Simpkins.

Toronto Chemical Mfg. Company, New York, has been incorporated with a capital of \$20,000 to manufacture chemicals. The incorporators are E. A. Eichner, J. M. Cuff, M. Moullou, 220 West 42nd Street.

United Chemical & Organic Products Company, has been incorporated in Delaware with a capital of \$2,292,700 to manufacture glues, gelatine, etc.

United Roll & Foundry Company, Ravenna, Ohio, has been incorporated with a capital of \$125,000. C. E. Yost, incorporator.

U. S. Gun Oil Company, Beaumont, Texas, has been incorporated with a capital of \$20,000. The incorporators are E. T. Dickson, A. L. Dickinson, J. M. Johnson.

Van Wert Foundry Company, Van Wert, Ohio, has been incorporated with a capital of \$15,000. I. W. Langwell, incorporator.

Waters Oil Company, Delaware, has been incorporated with a capital of \$1,000,000 to acquire oil and gas lands and to develop the same. The incorporators are M. L. Gatchell, L. A. Irwin, H. W. Davis.

The Wood-Perical Chemical Corporation, Richmond, Va., has filed articles of incorporation with capital of \$300,000 to manufacture chemicals.

Changes in Capitalization

The Ammonol Chemical Company, New York, has reduced its capital from \$100,000 to \$10,000.

The Chile Copper Company, New York, has increased its capital stock from \$110,000,000 to \$125,000,000.

The Hoffman-LaRoche Chemical Works, 440 Washington Street, New York, has increased its capital from \$25,000 to \$125,000 for expansion.

Houston Gas & Fuel Company, Houston, has increased its capital stock from \$2,000,000 to \$2,100,000.

The Jenkins Manufacturing Company, 35 Farrand Street, Bloomfield, N. J., has increased its capital from \$150,000 to \$600,000. The company engages in the manufacture of brass goods.

E. C. Kilpstein & Sons Company, Chrome, N. J., manufacturer of chemicals and dyestuffs, has increased capital from \$100,000 to \$1,000,000 for expansion.

The Lubricating Metal Company, 2 Rector Street, New York, has increased capital from \$100,000 to \$500,000 for extensions.

The Nitrogen Products Company, Providence, R. I., has increased its capital from \$200,000 to \$500,000.

The Ohio Steel Company, Lima, has increased its capital from \$1,300,000 to \$1,500,000.

The Oklahoma Producing & Refining Company, 14 Wall Street, New York, a Delaware corporation, has increased its capital from \$5,000,000 to \$10,000,000 for extensions.

The W. S. Rockwell Company, Balls Lane, Newark, N. J., manufacturer of furnaces, has increased its capital from \$100,000 to \$525,000 for business extensions.

The Utica Chemical Company, Utica, N. Y., has increased its capital from \$30,000 to \$200,000 for expansion.

Construction and Operation

California

FRESNO.—The Pacific Gas & Electric Company will build a new gas plant which is to cost \$100,000. It will contain a generator invented by E. G. Jones, and known as the Jones Improved oil gas set. It is claimed that this machine can make two million feet of gas per day.

KENNETT.—The electrolytic zinc plant of the Kennett Copper Company was started up in the first week of April, but will not be in complete operation until some time this month. The total cost of the plant was about \$500,000.

LOS ANGELES.—Petitions have been sent to the City Council, calling upon Los Angeles to turn over to the Federal Government electric power produced at generating station No. 1 of the Aqueduct for the purpose of making nitric acid. It has been figured that about 70 tons per day of 70-per-cent acid could be made from the electricity generated at this station. The current is now used by the city.

LOS ANGELES.—The Union Oil Company has been authorized by the Commissioner of Corporations to raise \$3,500,000 for the purpose of buying additional oil lands, building a new refinery, and extending its selling facilities.

Connecticut

BRIDGEPORT.—The Bullard Machine Tool Company of Bridgeport has purchased the J. A. Taylor Gray Iron Casting & Foundry Company's property in Fairfield. The property consists of the foundry plant and about 9 acres of land, which will allow for expansion. Joseph A. Taylor of Port Chester, N. Y., is president of this company.

WATERBURY.—The Waterbury Rollings Mills Company has started work on three additions to its plant. The buildings will be one story high.

Idaho

BURKE.—The Hecla Mining Company has entered into a contract with the Bunker Hill & Sullivan Mining & Concentrating Company for the treatment of its ore, arrangement to become effective as soon as the Kellogg smelter is opened.

KELOGG.—The Bunker Hill & Sullivan Mining & Concentrating Company, here, plans to have its \$1,000,000 smelter ready to blow in early in May, according to Stanley A. Easton, general manager.

Illinois

JOLIET.—The Standard Paint Company of New York City, which operates eight factories in various parts of the country, will erect its ninth plant in Joliet. The company has purchased 20 acres of land north of the Phoenix Horseshoe Company's plant, and will commence construction in the near future. The company manufactures roofings, insulating papers and waterproofing. Its other plants are located in Bound Brook, N. J., Los Angeles and Oakland, Cal., Seattle, Wash., Chicago Heights, and Montreal, Canada.

Indiana

VINCENNES.—The Sanders Oil Company of Chicago has purchased the holdings of the Allen Dale Oil Company, owner of several producing oil wells in Wabash County, Ill., for \$750,000.

Kentucky

LOUISVILLE.—The Louisville Varnish Company will erect a three-story varnish factory to cost \$37,000.

Massachusetts

WORCESTER.—A new company which will probably be known as the Worcester Foundry Company will erect a plant in

this city to cost \$50,000. Both brass and iron castings will be made. A large brass foundry in Waterbury, Conn., is interested in this company.

Michigan

PORT HURON.—The Summers Fiber Company of this place will erect a permanent flax station at Sandusky. An acreage of 1000 will be required.

Missouri

ALTON.—The Lacleda Steel Company has begun the erection of a third open-hearth furnace. Plans are also under way for the construction of additional soaking pits.

New Jersey

NEWARK.—The West Pulverizing Company has purchased from the General Leather Company a plot of three acres on Evergreen Avenue, near the Pennsylvania Railroad. The company conducts a general marine and foundry business in addition to its pulverizing equipment. The members of the company are A. Lincoln West, W. G. West and Frank R. West, all of Newark.

PASSAIC.—The Pantasote Leather Company will erect a one-story addition to its factory in Jefferson Street.

IRVINGTON (Newark).—Jeremiah Carnfield has filed plans for the erection of a new foundry at 33 Glorieux Street, to cost about \$7,000.

NEWARK.—The Maas & Waldstein Company, 437 Riverside Avenue, manufacturer of chemicals, is building two one-story additions, 30 x 100 ft.

NEWARK.—The Butterworth-Judson Company, Avenue R, manufacturer of chemicals, etc., will make improvements in its phenol plant, which has recently been closed, primarily for this purpose.

NEWARK.—The Rubber & Celluloid Manufacturing Company, 56 Ferry Street, will build a one and two-story addition, about 50 x 40 ft., to its plant. This company has recently filed notice of a change in name to the Rubber Celluloid Products Company.

PERTH AMBOY.—The American Smelting & Refining Company will erect a large building to cost \$80,000 and will be known as a general utility building.

TRENTON.—The New Jersey Chemical Company recently incorporated with capital of \$25,000, manufacturers of special chemicals used in the production of paint, is now considering sites for the erection of a local plant. The company has been maintaining an experimental plant at 145 North Willow Street. David Berkow, president.

New York

POUGHKEEPSIE.—The Century Steel Company will erect a new plant in Delaware Street. Mr. William E. Dukeshire, secretary and treasurer of the corporation.

NEW YORK CITY.—At a recent meeting of the directors of the new National Aniline & Chemical Company, Inc., it was decided to make the Schoellkopf Aniline & Chemical Works, Buffalo, the assembling and shipping point for finished products. The Benzol Products Company, which is included in the consolidation, is erecting a large still house at its plant at Marcus Hook, Pa. Work on the new buildings at the Beckers' Aniline & Chemical Works in Brooklyn will be pushed as rapidly as possible. It is probable that the Schoellkopf Company will retain their name, as they are so well known in the trade.

SYRACUSE.—The Syracuse Malleable Iron Works, 101 North Geddes Street, manufacturers of metal wheels for automobile trucks, has commenced the erection of a new addition to its plant, to cost about \$15,000. Burns Lyman Smith is president.

North Carolina

PORTSMOUTH.—The Portsmouth Fish-canning Company, recently incorporated with \$50,000 capital, will manufacture fish scrap and oil at this place.

Ohio

CLEVELAND.—The Hydraulic Press Steel Company is planning to acquire a steel plant with an annual capacity of 250,000 tons. The company is desirous of having a complete plant, from the raw material to the finished product.

COLUMBUS.—The Smith Gas Engineering Company of Lexington, Ohio, is installing one of its single six-section gas producers in the plant of the Jeffrey Manufacturing Company of Columbus, Ohio. The producer gas will be used for both power and heating.

ELYRIA.—The Elyria Iron & Steel Company plan additions to its local plant, which will involve an expenditure of between \$500,000 and \$750,000. The main addition will be a 180 x 200-foot building for a rolling plate mill. A club house and furnace department will be added later.

TOLEDO.—The Libby Glass Company will erect an addition to its plant for the manufacture of electric light bulbs. The addition will cost \$45,000.

TOLEDO.—The Taylor Coupler & Steel Castings Company is building a new plant in Ironville. Mr. C. C. Taylor of 542 Ohio Building is president of the company.

YOUNGSTOWN.—The Trussed Concrete Steel Company is planning extensive additions to its plant, to take care of increasing business.

Oregon

EASTSIDE.—F. C. Harbaugh, Frank Kester and Fred Blaise, all of Marshfield, are completing plans for construction of a charcoal and chemical plant in this city, which will be later developed into a powder plant. Alderwood and mill waste will be utilized in the plant.

GOLD HILL.—The Ray & Haff Scheldite mine, George Stone, manager, is installing compressors and drills on the property. Machinery will be operated by electric power.

PORTLAND.—The Standard Electric Power & Chemical Company recently organized with \$4,000,000 capital, has a power plant in Central Oregon. The factory has not yet started. The officers are V. H. Dent, president, manager of the Trogon Powder Company; B. H. Fisher, secretary, dentist, Portland, Ore., and John A. Jeffrey, vice-president, C. D. Charles, general manager. The parties are all of Portland, Ore., except Mr. D. F. Smith of Vancouver, who is one of the trustees. The company's plant will develop, and its factory means to use the greater portion of 300,000 hp. to be employed in the production of atmospheric nitrate of lime and nitric acid; also a standard fertilizer with guaranteed 40 per cent nitrate and 35 per cent potash and 22 per cent phosphoric acid. It also proposes to go quite extensively into the extraction and preparation of all coal tar by-products.

Pennsylvania

MARCUS HOOK.—The Benzol Products Company has begun the erection of a large stillhouse at its plant here. Other extensions to the plant are looked for in the near future, as the company has recently been merged into the new National Aniline & Chemical Company, Inc., of New York.

PHILADELPHIA.—The Atlantic Drier & Varnish Company has acquired a new one-story plant at Wolf and Weacoco Avenues, 237 x 200 ft., to be used for manufacturing.

PHILADELPHIA.—The Westmoreland Chemical & Color Company has filed plans for alterations and improvements in its plant on Twenty-second and Westmoreland Streets.

PHILADELPHIA.—Frederick Weber & Company, manufacturers of paper, will soon commence the erection of a five-story and basement addition, 45 x 150 ft., at Buttonwood and Hamilton Streets.

PHILADELPHIA.—Philadelphia Paper Company has filed plans for the erection of a one-story brick addition, 58 x 58 ft., on Nixon and Fountain Streets.

PHILADELPHIA.—M. Collins & Company, 226 Columbia Avenue, manufacturers of paper, will build a two-story brick and steel addition, about 40 x 50 ft.

READING.—H. J. Hayden and Charles M. Hallman, formerly connected with American Iron & Steel Company, have acquired property at Lebanon, and will establish a plant for the manufacture of glazed paper.

SOUTH BETHLEHEM.—The chemical laboratory, pattern storage plant and boiler house of the Bethlehem Foundry & Machine Company was recently destroyed by fire. The buildings will be immediately replaced.

WHITEHAVEN.—Wilmot Engineering Company, Hazleton, will build an addition to its foundry at Whitehaven, used for the production of iron and steel castings.

Washington

ABERDEEN.—A new paper company, of which C. M. Weatherwax, manager of the Aberdeen Lumber & Sawmill Company, is one of the promoters, plans the erection of a paper and pulp mill at this place which will cost \$1,000,000. An effort will be made to have it in operation by January, 1918.

CAMAS.—Entire plant of the Crown-Willamette Paper Company has been closed for a week on account of strike of more than 500 men for increased wages of 50 cents a day. Company has posted notices that plant will be closed indefinitely. Plant operates 24 hours, and is rushed with orders.

SEATTLE.—The Seattle Brewing & Malting Company, whose plant in Georgetown formerly produced 1250 bbl. of beer per day, and which became idle when the manufacture of beer was abolished in Washington, has taken up the manufacture of "near beer" and industrial alcohol. The plant covers 12 acres, and is located in value \$1,000,000 on account of becoming idle. The new industry promises to be successful and uses a process invented by D. Cozzolino of Los Angeles, who has written to us as follows regarding same:

"In regard to our process, I wish to say that I take advantage of the capillary attraction of linen, and of the laws of aphyrometry. In order to take the alcohol from beer (this is the only successful process in making a non-alcoholic beer), the apparatus must be obtained at low temperature, otherwise the albuminoids will be coagulated, impairing the foam stability of the beer, and giving a cooked taste to the product.

"A vacuum process therefore is necessary, and our vacuum apparatus is so designed as to separate the alcohol from the spent draught in very few sheets, through capillary attraction, to the upper part of the vacuum apparatus, while the foaming is kept in check by a linen diaphragm which presents a physical obstacle to the foam, breaking the bubbles, and dissolving those that escape the diaphragm as soon as they reach the cold zone. This cold zone is formed by the evaporating linen sheets during the evaporation of the alcoholic vapors, drawn up by the capillary attraction process.

"The alcohol vapors are separated and condensed in a receiver. By our system a finished beer is separated in two products, alcohol on one side, and what was the beer before, minus the alcohol, on the other side. All odiferous matter, aroma, ethers, and other non-condensable pleasant odors are caught in a trap, and sent back to the de-alcoholized beer. The analysis rigorously made show that our product is a real beer, having all the parts and ingredients of the old beer, minus the alcohol only. It sparkles, foams, looks, tastes and acts on the body as a regular beer, minus the unpleasant effects of the alcohol.

"All the near beers on the market now belong to two classes, the non-fermented and the fermented class. The first one, which is the cheapest and simplest way of preparing a near beer is the class of near beer made in Germany. The makers of the United States of America in their first crude attempt in this branch of the industry.

"The second class of near beer is divided in two parts. The first part ferments its beer, but takes the alcohol out by open boiling or by vacuum process at high temperature of about 150 deg. Fahr. These brewers make a near beer that is better than the first, but they do not ferment their product. The second part of the second class of near beers uses very low temperature and produces the real non-alcoholic beers. Of these processes, the only one successful operation is the White Ribbon Beer Company's process of Los Angeles, Cal., which is the successful pioneer in this line. Three large breweries have taken up their system, and all three make a splendid product. The White Ribbon Beer Company's process is divided in two parts. The mechanical part of the first part is strong patent issued and pending, and the finishing part, which is secret."

"If the 'near beer' can be successfully made, it should be a big thing for our breweries which may all have to stop making beer. The Seattle Company has faith in its new venture, and plans to turn out 1000 bbl. of near beer daily. Besides the alcohol, which they will denature, and other by-products."

SEATTLE.—The Sound Paper Company, Seattle, recently incorporated for \$5,000,000 with New York and Scott Calhoun and F. P. Weston of Seattle, plans development of the Sultan River power project and establishment of an near Seattle, of a paper mill that will utilize 400,000 ft. of timber daily. The ultimate development of the power project and paper mill, which will be devoted entirely to production of newspaper print paper and book paper, is \$12,000,000. The only obstacle now in the way of the project is certain claims that the city of Seattle has on the power site.

SPOKANE.—The Lucky Jim Zinc Mines, Spokane, Wash., plans the erection of a concentrating plant with capacity of 700 tons daily, and other improvements.

SPOKANE.—Northwest Mining Association recently convened here, with President Graham B. Dennis at the head, for the purpose of discussing the establishment of an electrolytic zinc plant near Spokane for the reduction of zinc ores. Carefully prepared estimate of cost of such plant was given, placing the cost at \$400,000. Committee has been appointed by President Dennis to take up details of investigation.

VALLEY.—American Mineral Production Company, H. H. Brant, manager, will commence work at once in proposed extensive developments of magnesite properties in that district. A fleet of seven motor trucks will be used in hauling magnesite from the quarries to Valley. Site has been secured and plans completed for construction of laboratory, office and warehouse at Valley to cost \$20,000.

WHEELING.—Col. A. M. Schenk of Wheeling has purchased a glass plant at Martin's Ferry, Ohio, and will move same to Charleston.

West Virginia

CLARKSBURG.—The Bridgeport Window Glass Company, recently incorporated, will construct a window glass plant in Bridgeport, to cost \$100,000. The company has secured control of a large tract of land in territory near Bridgeport, which will insure an adequate supply of natural gas.

Wisconsin

APPLETON.—The Bergstrom Paper Company is planning a large addition to its mill. The new structure will be two stories high and will be located between the old mill and the city, utilizing part of the space remaining between the two buildings.

Wyoming

CASPER.—The plant of the Midwest Refining Company at Casper, when additions are completed, will be the largest refinery in the West, and one of the largest in the world, with capacity of 50,000 bbl. of crude per twenty-four hours. The Standard Oil Company of Indiana will also erect a large addition to its refinery in order to take care of the increased output of refined oil from the Midwest plant. The plant of the Standard Oil Company of Casper is the largest refinery of its kind in the world producing motor spirits from fuel oil.

Alaska

FAIRBANKS.—The Fairbanks station of the United States Bureau of Mines will soon be opened. Machinery and equipment is now arriving in Seattle, and will be forwarded on the early boats for Alaska. The station will be in charge of Mr. John A. Davis. It will be similar to the stations at Seattle, Wash., and Tucson, Ariz.

Manufacturers' Notes

OUR TRADE WITH BOLIVIA.—The United States is now the chief supplier of Bolivia's imports, according to a report of American Minister John D. O'Rear, published in Commerce Reports. Until 1914 it was fourth in importance. Chemical products form a very small part of the imports. In 1915 the value was 13,545 bolivianos (the normal value of the boliviano is \$0.3935). Of this amount the United States supplied 2,276 bolivianos. Other items are as follows: Explosives: total \$01,629b.; from U. S. \$67,645b.; from U. S. 133,499b.; from U. S. \$5,733b.; Leather: total \$3,246b.; from U. S. 1,315.6b.; Gasoline: naphtha, etc., total \$3,245b.; from U. S. 2,726b.; Kerosene: total \$2,859b.; from U. S. 2,555b.; Petroleum, crude: total 224,354b.; from U. S. 132,706b.; Paints, colors and varnishes: total \$3,606b.; from U. S. 6847b.; Resins, gums and varnishes: total 45,455b.; from U. S. 21,367b.

Tin has been the principal item of Bolivian export for many years, the bulk of the production having been shipped to Great Britain, even after the war broke out. During 1915 about 35,360 metric tons of 2294 pounds of tin ore were sold to Great Britain, and the United States, which held second place on the list of buyers, re-

ceived only about 1100 tons. During 1916, however, the United States purchased this mineral in increasing quantities, and it is estimated that about one-half of Bolivia's production is now being sent to the United States. The total exportation of this ore during 1915 was about 36,492 tons. In addition to the exports to Great Britain and the United States, Germany took 27 tons, Argentina, 2 tons, and Uruguay and Chile, 14 tons.

Bolivia holds second place among the tin-producing centers of the world, and many good mines and prospects are still open to development that would be attractive to American capital. If modern methods were introduced in the development of the mines, Bolivia's production would increase greatly, as the methods at present employed, with few exceptions, are primitive.

The enhanced prices obtained for tungsten ore caused the opening up of large deposits in the northern part of the country, where they abound. The output during 1914 was 276 metric tons, while in 1915 the exports totaled 732½ tons, of which the U. S. took 436 tons and Great Britain 20 tons. The production of antimony during 1915 was large. Great Britain received 16,184 tons, the U. S. 1589 tons, and Spain a small amount.

In the table below is shown the value of Bolivian exports, by countries, in 1913, 1914 and 1915.

The remarkable increase in the purchases made by the United States during 1915 over those of the preceding year is largely due to the diversion of about three-fourths of the crude rubber, formerly exported to Liverpool, to New York and, in the second place, to purchases of Bolivian tin, copper, tungsten, and other minerals for United States industries. The entrance of the American Smelting & Refining Co. into Bolivia as a buyer of ores and concentrates, especially tin and copper, accounts for much of this increase.

THE J. H. DAY CO., Cincinnati, Ohio, manufacturers of mixing, kneading and grinding machinery, has acquired the business and plant of the Lynn-Superior Co., Cincinnati, Ohio, manufacturers of similar machinery.

THE KNICKERBOCKER LIME CO., Philadelphia, has retained the Schaffer Engineering & Equipment Co. of Tiffin to design and install its plant equipment, which will include the Schaffer Continuous Hydrator and the Poidometer, both of which were developed by the latter concern.

THE SUPPLEE-BIDDLE HARDWARE COMPANY, Philadelphia, Pa., has recently taken up the manufacture of high grade filter and bolting cloths for chemical and metallurgical use. The cloths are made of monel metal and also of copper and bronze.

THE CHEMICAL CONSTRUCTION COMPANY, Charleston, W. Va., has opened a New York office at 30 E. 42d Street, under the direct supervision of Mr. T. C. Oliver, manager of the company. This company has recently doubled its capital stock owing to greatly increased business.

USES OF ROSIN.—The Leather and Paper Laboratory of the U. S. Dept. of Agriculture has prepared a list of uses of rosin in the leather and paper fields, some of which may not be generally known. The uses of turpentine were given in our last issue. The uses of rosin, acetic acid and pitch follow:

USES OF ROSIN.

Manufacture of rosin soaps, including: Laundry soaps and soap powders. Sizing for paper and paper board. Paint dryers (resinates of lead manganese, cobalt and other metals, Japan driers). Axle grease. Waterproofing compounds (insoluble rosin soaps). Emulsifiable oils (lubricants for high-speed tool work). Leather dressings and shoe polishes. Enamels used in ceramics (resinates of heavy metals). Manufacture of certain varnishes and lacquers. Manufacture of plastic compositions, including: Sealing waxes. Cores for foundry work. Tubing substitutes. Shoemaker's wax.

EXPORTS FROM BOLIVIA

Countries	1913	1914	1915
Great Britain.....	\$30,305,731	\$20,774,500	\$26,654,735
Germany.....	3,189,496	1,475,977	25,655
France.....	1,834,524	1,100,000	336,920
Belgium.....	1,268,894	755,066	
Argentina.....	365,538	354,199	579,060
Chile.....	236,177	496,178	243,890
United States.....	228,791	10,000,000	23,684
All other countries.....	70,227	420,537	246,644
Total.....	\$37,488,605	\$26,320,458	\$38,054,144

Briquettes and fire kindlers.
Artificial wood.
Composition for pattern making.
Paper-maché.
Brewers' pitch.
Roofing cement.
Grafting wax for trees.
Cheap linoleum and oil cloth.
In shoe bottom fillers.
Lutes.
Pharmaceutical purposes, including:
Ointments.
Plasters.
Cerates.
Internal remedies (veterinary).
Disinfecting compounds.
Making roofing materials.
Adulteration of ceresin and paraffin waxes.
Adulteration of beeswax and "artificial beeswax."
Adulteration of shellac and certain resins.
Manufacture of Venice turpentine substitute.
Flux for soldering and tin plating.
Dusting molds in foundries.
In dry batteries and electrical insulation (twirling).
Constituent of wood stains.
In belting grease.
On leather belts to prevent slipping (use inadvisable).
On violin bows.
For setting bottles in hair brushes.
Constituent of insect powders.
For the manufacture of "artificial copal."
In steel hardening.
Constituent for enamel for brick walls.
Coating for match splints.
Constituent for some floor waxes and polishes.
In wax tapers.
Hardening tallow candles.
In stamping powders.
Sizing for wood-pulp wall-board.
In waterproofing compositions for paper, card board and fabrics.
Paper hangers' size.
Making imitation Burgundy pitch.
Manufacture of partitions (filling vacant space in shrapnel).
Manufacture of sticky fly-paper.
Constituent of sweeping compounds.
Weather-proofing wooden fence posts.
In mixtures to protect trees from climbing insects.
Constituent of printing inks.
In cements (for glass, etc.).
For caulking ships.
In sulphite-waste utilization (Tripple process).
In the manufacture of condensation products.
As a raw material for producing certain chemicals (benzene derivatives).
In the manufacture of carbondust and calcium carbide (using sawdust and refuse wood chips with residues from the manufacture of turpentine and rosin).
In destructive distillation to produce:
Rosin oil and rosin oil products used in:
Cements.
Lubricants (oils and axle grease).
Printing inks.
Adulterating linseed oil.
Brewers' pitch.
Varnishes.
Rubber substitutes.
Funnel paints for cauchs.
Flotation concentration of ore.
Mixtures to protect trees from climbing insects.
Shingle stains.
Waterproofing textiles and cordages.
Manufacture of lamp-black for lithographic purposes.
Soap making.
Leather dressings and shoe polishes.
Sweeping compounds.
Adulterating olive oil and castor oil.
Rosin spirits used in:
Illuminants.
Turpentine substitutes.
Cheap varnishes.
Acetic acid used for making:
Acetate of lime (source of acetone).
Acetate of iron (mordant and mineral dye).
Acetate of alumina (waterproofing cloth).
Pitch, used for:
Cobblers' wax.
Preserving cordage and nets.
Roofing felts and waterproof papers.
Bituminous paints.
Binder in briquettes.
Caulking ships.
Cements, lutes.
Electrical insulations (dry batteries, wiring, etc.).
Plastics for pattern making.
Grafting wax for trees.
Paving materials.
Steel hardening compositions.
Waterproof masonry.

PRODUCTION OF PLATINUM IN 1916.—Preliminary estimates based on practically complete returns made by the United States Geological Survey by domestic refiners of platinum indicate that in 1916 approximately 485 oz. of domestic crude platinum (about 74 per cent metal) were re-

finned producing 172 oz. platinum, 84 oz. of iridium, and 113 oz. of iridosmine, and that 10,113 oz. of South American crude platinum, 38 per cent pure, were refined. The platinum metals produced by refining crude placer platinum, of both foreign and domestic origin, amounted to 3,133 oz. platinum, 335 oz. iridium, 139 oz. iridosmine, and 18 oz. palladium. Refiners of copper matte and gold bullion report a production from foreign and domestic material of 2558 oz. platinum, 100 oz. iridium, and 2746 oz. palladium. About half of this output was produced from domestic materials.

The total production of new platinum metal in 1916 was about 11,500 oz. of platinum, 335 oz. iridium, 200 oz. iridosmine, and 2765 oz. palladium. The scrap platinum metals sold in the United States in 1916 amounted to approximately 42,000 oz. of platinum, 880 oz. iridium, and 2000 oz. palladium.

BAUXITE SHIPMENTS FROM BRITISH GUIANA.—Bauxite in considerable quantities has been discovered in British Guiana, according to the Annual Report. Prospecting and development work has been carried on for the past two and one-half years with satisfactory results, and to-day the shipment of this product is being made, a full cargo of 980 tons being sent to consignees in the United States. Development work has now reached a stage where steady output is being made, and shipments are expected to follow at frequent intervals.

BAUXITE IN 1916.—The production of bauxite, the ore of aluminum, in 1916 was 425,359 long tons, which had a value of \$2,297,825, an increase of 43 per cent in quantity and 52 per cent in value over 1915. This is a notable increase for the whole United States, but the most striking figures are those for Georgia and Arkansas, and 1915 the production of bauxite in these two States was 25,008 long tons. The output was increased to 46,410 long tons in 1916, a gain of 85 per cent. A large part of this increase is due to the operation of new and old mines in central Georgia notably in Wilkinson, Meriwether and Sumter counties. The production of Arkansas, another well-known deposits in Arkansas. There has been much activity in Georgia and Alabama, where many newly found deposits were brought nearly to a producing stage in 1916. Advice received by the United States Geological Survey indicate that a number of old deposits in these States will be reopened, owing to the increased value of the ore and the fact that it is used by many new enterprises.

AMERICAN COTTONSEED PRODUCTS INDUSTRY.—Some idea of the immensity of the American cottonseed and cottonseed products industry can be obtained from the report issued by the Bureau of Census showing the quantity of cottonseed received at the mills from August 1, 1916, to March 31, 1917, was 4,330,922 tons, the quantity crushed during that period was 2,834,435 tons, and the quantity on hand at the mills March 31 was 452,066 tons. From August 1 to March 31 there were produced 1,186,609,174 lb. of crude oil and 955,345,973 lb. of refined oil. This refined oil was produced from 1,026,462,349 lb. of crude oil.

TO INCREASE THE SUPPLY OF TIN CANS. The steps that have been taken to increase the supply of tin cans for the coming packing season were announced recently by Secretary Redfield. They consist principally in speeding up the manufacture of tin plate, in arrangements by the manufacturers whereby much of the tin-plate ordinarily used in packing non-perishable goods will be diverted to the packers of perishable foods, and in the introduction of suitable substitute containers for many lines of non-perishable goods usually packed in tin cans. At present the canners are demanding 40 per cent more cans than the can manufacturers feel that they are able to produce.

The greatest saving in tin plate can be effected by using substitute containers for non-perishable goods, and the Department of Commerce, through the Bureau of Foreign and Domestic Commerce, is now comparing suggestions along this line. A great many familiar articles are put up in tin containers which can well be put up otherwise. Good substitutes are now being used for packing tobacco, coffee, tea, spices, baking powder, soap powder, white lead, powdered paints, sirup, cocoa, cheese, lard, butter, and peanut butter. It is suggested that packers of such products consider carefully the use of such substitutes before ordering any further supplies of tin cans. The Department will be glad to assist engineers who may state the special uses for which they wish containers to replace tin during the present emergency.

In some instances the use of substitutes may mean temporary inconvenience but no patriotic manufacturer will hesitate to "do his bit" to prevent a serious food shortage next winter. Some manufacturers who have been approached by the Department will be able to use substitutes without any sacrifice, whatever. In fact, some of them will welcome an opportunity to abandon the elaborate containers that have come into use largely for advertising purposes during the last few years. A number of important concerns are already notifying their trade that in the future their goods will be delivered in substitute containers. A number of tin-plate manufacturers have agreed to co-operate by refusing for the present to enter into new contracts for the sale of tin plate for use in canning non-perishable goods.

Economy in the manufacture of tin plate and tin cans is of prime importance and the manufacturers are making special efforts to prevent waste in the mills and factories.

The present high price of tin is attributed to the unusual demands of the last two or three years, combined with the present difficulty of getting the supplies from the Straits Settlements and from the tin refiners in Europe. Practically all of the world's supply of tin is mined in the Straits Settlements and the tin refiners of these years European firms have handled the output of both countries and sold the refined product to tin-plate manufacturers in Europe and the United States. Although since the war started, a smelting plant has been erected in New Jersey and the ore is now brought here direct from Bolivia. Another plant is also under construction on Long Island.

Manufacturers' Catalogs

CHALLENGE COMPANY, Batavia, Ill., has issued a little pamphlet describing briefly its wind mills, tanks, steel towers, pumps, engines, lawn swings, pump jacks, millage cutters, corn crushers, grinders, feed grinders, wood saws and settees.

THE FOUNDATION COMPANY, Woolworth Bldg., New York, has issued a booklet called "Industrial Plants," which gives photographs and descriptions of some of the chemical and other industrial plants erected by the company.

M. H. TREADWELL COMPANY, 140 Cedar St., New York, has issued a bulletin describing "Tread-Kill" grates for burning all grades of coal.

READING IRON COMPANY, Reading, Pa., has issued a booklet called "Additional Testimony in Case Wrough Iron Pipe vs. Steel Pipe," describing tests and advantages of the different pipes.

BLAIR, CAMPBELL, McLEAN, LTD., Woodville Street, Govan, Glasgow, Scotland, has issued a catalog describing their "Multiplex" film evaporator and "Simplex" film evaporator.

PYROELECTRIC INSTRUMENT COMPANY, 100 East State Street, Trenton, N. J., has issued a catalog on the Northrup pyrovolter describing their different instruments and giving a price list of same.

Other New Publications

REPORT ON THE PRICE OF GASOLINE IN 1915. Issued by the Federal Trade Commission, April 11, 1917.

A PRELIMINARY STUDY OF THE ALLOYS OF CHROMIUM, COPPER AND NICKEL. By D. F. McFarland and O. E. Harder. Bulletin No. 93, issued by the Engineering Experiment Station at the University of Illinois.

MINERAL PRODUCTION OF THE UNITED STATES IN 1915. Introduction by H. D. McCaskey and summary by Martha B. Clark. Issued April 16, 1917, by the Department of the Interior, United States Geological Survey, Washington, D. C.

INDUSTRIAL HEATING AS A CENTRAL STATION LOAD. Published by The Society for Electrical Development in two parts. This is Part I and deals with electrical furnaces.

STRUCTURE OF THE COATING ON TINNED SHEET COPPER IN RELATION TO A SPECIFIC CASE OF CORROSION. By Paul D. Merica. Technologic Paper No. 30, Bureau of Standards.

CLAY DEPOSITS NEAR MOUNTAIN GLEN, UNION COUNTY, ILLINOIS. By Stuart St. Clair. This is an extract from Bulletin No. 36, issued by the State of Illinois. State Geological Survey, Urbana.

ASPHALTUM BLASTFURNACE GAS. Technical Paper 100, Bureau of Mines, Department of the Interior, written by Frederick H. Wilcox.

Metallurgical and Chemical Engineering

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Contents for June 1, 1917

EDITORIAL:	
Government Price Fixing	625
Second Class Postal Rates	626
Steel Production in 1916	626
An Interesting Japanese Contemporary	626
READERS' VIEWS AND COMMENTS:	
Aluminum Production of Canada. By Theo. C. Denis.....	628
A Fable It Will See in Years to Come.....	628
Coming Meetings and Events.....	628
Flotation Suit Decision of Appellate Court in Miami Case.....	629
Annual Meeting of American Iron and Steel Institute.....	629
New York Section of Society of Chemical Industry.....	630
The Petroleum and Gasoline Situation. By Van H. Manning.....	630
Bureau of Standards Analyzed Samples.....	631
The Western Metallurgical Field.....	632
Military Census of New York City's Factories and Mercantile Establishments	632
Personnel of Council of National Defense and Its Advisory Commission	633
Electrochemists Supporting the Government.....	633
Presidential Address to the American Iron and Steel Institute. By Elbert H. Gary.....	634
Chemical Reactions of Iron Smelting. By Walther Mathesius.....	636
Buffalo Meeting of American Institute of Chemical Engineers.....	640
American Gear Manufacturers' Association Convention.....	640
The Call for the Chemist. By Prof. Herbert R. Moody.....	641
The Cracking of Petroleum in the Liquid Phase. By Roy Cross	643
Notes Upon the Hydrometallurgical and Electrolytic Treat- ment of Zinc Ore. By E. E. Watts.....	645
Note on the Thermocouple Nichrome-Constantan. By R. W. Woodward and T. R. Harrison.....	647
Some Theoretical Aspects of Electrical Fume Precipitation. By W. W. Strong.....	648
Potash from Cement Mills.....	653
Grading of Graphite, Gunpowder and Malt. By Edward S. Wiard	654
Specific Gravity in Rubber Compounding. By Andrew H. King.....	655
SYNOPSIS OF RECENT METALLURGICAL AND CHEMICAL LITERA- TURE	657
RECENT METALLURGICAL & CHEMICAL PATENTS.....	659
A Combined Steam Turbine and Centrifugal Boiler Feed Pump	660
New Design of Dust Collector.....	662
New Foundry for Iron and Steel Castings.....	663
BOOK REVIEWS	663
PERSONAL	665
Current Market Reports—The Iron and Steel, Non-Ferrous, and Chemical Markets and Chemical Price List.....	665
Industrial—Financial, Construction and Operation, and Manu- facturers' Notes	669

Government Price Fixing

Since our entrance into the war developments have been so rapid that the opinion that there will be no need for the Government to regulate prices has come to be somewhat less strongly held, and probably it will not be long until a very decided change in opinion will be noticeable.

In many quarters fears have been expressed that the Government would place such large taxes on "excess profits" that business would be injured, that the taxes upon prosperity might be so great as to curtail the prosperity. Now the tax upon some manufacturers or consumers through sharp price advances may be found to be a much more potent influence to throttle their activities than any tax upon excess profits could be.

Suppose, for instance, a manufacturing line in which there are manufacturers with raw materials on contract at $10n$. Other expenses are $2n$ making a cost of $12n$. The selling price is $16n$, and a normal profit of $2n$ is allowed, leaving excess profits of $2n$ on which, say, an excess profits tax of 50 per cent is levied. Then the tax paid is n .

Assume another manufacturer who chances not to be provided with a similar contract for raw materials, and is forced to pay $15n$ for his raw material. In present conditions there are wide divergences in the cost of material to different buyers, by reason of some having contracted more freely than others. This manufacturer's cost is $17n$ and his selling price $16n$ so that his loss is n . One pays a heavy excess profits tax and still has profits of $3n$, while the other loses n . Is the manufacturer who is taxed put out of business?

In the above case the assumption is merely that one buyer pays 50 per cent more for his raw material than another. In the steel industry there is no doubt whatever that in many cases present market prices on certain commodities for early deliveries are much more than 50 per cent in excess of prices at which similar steel is being shipped, against contracts made months ago. An excess profits tax must fall equally upon all competitors, except to the extent that it reduces the amount by which the profits of some exceed the profits of others. The difference in the cost of raw materials falls very unequally and may easily result in some manufacturers being forced to curtail their operations, or cause them an actual loss.

It is a notorious fact that the prices of some commodities in the United States have risen above the level at which prices in England were arrested by Government control, and yet the trend is still upwards.

Any borrower is unfortunate if he is compelled to borrow money when money is cheap and plentiful and repay it when money is scarce. The government converts the

major portion of the money it borrows into commodities, at high prices. If when it repays the loan the commodities are much cheaper the transaction has a very unfortunate element in it. There is reason to believe that soon there will be clearer vision on this subject and that the sentiment in favor of Government price regulation in certain commodities will grow until it becomes really formidable.

Second-Class Postage Rates

There is before Congress a proposition to change the whole second-class postage system for newspapers and periodicals by dividing the country into eight zones and providing increased rates for greater distances. It is a plain war measure. The war requires severe taxation, and the best that can be said for the measure is that if enacted into law it would indeed be effective in raising the average second-class rate; careful analysis for a number of technical journals in various industries shows that the average increase in postage for them would be 250 per cent. But it is certain that the total receipts in dollars and cents by the Government for second-class postage would not be raised to any such extent. First, a number of publishers would undoubtedly be forced to go out of business since after the increase in cost of paper, ink, printing and general operating expenses they would not be able to pay 250 per cent more for postage. Second, the editions would undoubtedly be cut down for the stronger journals able to stand the strain.

The publishers do not object to taxation—severe taxation. They are willing to pay their full share of the cost of the war. But they object to a form of taxation that impairs the usefulness of the technical press at its very root—its fundamental ability to render service. This concerns our readers as much as ourselves. American technical journals are serious journals; in imparting information they connect the East and the West and the South; they connect theory and practice, and they connect different professions, different industries with each other. They are institutions with a true sense of responsibility for the advance of the art. They are the leaders in their respective industries. In this critical time of our country they stand ready to act as an arm of the Government to get the needs of the Government before the industries. They are the educational tools that nationalize the American industries. Nationalized American industry must in the end be the prime factor deciding the war. Can Congress afford to spoil this unifying nationalizing tool by a narrow-minded sectionalizing scheme? Can Congress afford to paralyze the national service of the technical press in a vital hour? It would seem unthinkable.

Steel Production in 1916

The official statistics of steel production in 1916 have just been made public by the Bureau of Statistics of the American Iron and Steel Institute. Our review of the year, in our Jan. 1 issue, commented on the fact the production broke former records by 32 per cent, and there is no occasion to make further reference, as

our estimates then made prove to have been surprisingly close. We estimated the production of steel ingots and castings at 42,500,000 gross tons, the official figure now made public six months later being 42,773,680 tons, or two-thirds of 1 per cent greater, while our estimate of rolled steel was 30,500,000 tons, and the official figure now proves to be 30,557,818 tons, or one-fifth per cent greater. Rolled iron was 1,822,571 tons, against our estimate of 1,500,000 tons. It is always difficult to tell what the iron mills will do. They made 2,200,086 tons of rolled iron in 1907, and dropped to 1,167,776 tons in 1914, while the rolled-steel production was substantially the same in the two years.

Bessemer steel had a sudden revival in 1916, with 11,059,039 tons of ingots and castings. After the production of 12,275,830 tons in 1906, and 11,667,549 tons in 1907, the industry seemed decidedly decadent, but despite the abandonment of a number of converters, and the diversion of some to the practice of the duplex process, the industry came back quite well under the stress for tonnage in 1916. An interesting fact is that some mills have found that with converter and open-hearth furnace capacity designed for duplexing they have been able to secure a greater tonnage output by operating separately. As many consumers were glad to get Bessemer in 1916, there was no hesitation in splitting up the departments. The production of duplex steel in 1916, however, was more than one-half greater than in any previous year, being 3,436,457 tons, against 2,210,718 tons in 1913.

The production of steel castings in 1916 was 1,371,763 tons, against a previous record of 1,020,744 tons, made in 1913.

Comparatively speaking, all iron and steel production records in 1916 sank into insignificance before the gain made in the production of electric steel, which was almost two and one-half times that of any previous year, chiefly by reason of the Steel Corporation's new capacity at the Duquesne and South Works. Electric steel production has been as follows, in gross tons:

	Ingots	Castings	Total	Ingots	Castings	Total
1909...	13,456	306	13,762	1913...	20,973	30,180
1910...	50,821	1,820	52,641	1914...	15,458	8,551
1911...	27,227	1,878	29,105	1915...	46,348	24,009
1912...	14,147	4,162	18,309	1916...	126,048	69,412
					42,870	168,918

An Interesting Japanese Contemporary

In a late issue we paid our respects to a new contemporary from Japan which bears the title of *The Chemical Technology*, a monthly journal of chemistry and chemical industry. Now, the tardy mails have brought additional numbers, and we take this occasion to repeat and extend our acknowledgments. The covers are printed in three colors; the advertisements and part of the text in two. The subscription price is ¥3.36 per year, which we figure at \$1.68. We do not like to give away secrets, but we doubt if any American publisher could get that monthly issue out at the price with all the color work. The magazine starts at both ends; at what they call the back in Japanese, and at what we call the back in English. The editor, Dr. H. Nishida of

Tokyo, where it is published, deserves great credit, and we felicitate him again on his accomplishment.

Alas, we confess that except for the short English part, which covers only four or five pages, we cannot read it. Let us quote a little and abstract a little, for even the short notes in English are illuminating and abound in information. We have already printed in full in our issue of May 1 (page 505) Dr. Nishida's comments on the dyestuff, synthetic medicine, wood products, glass, celluloid, paper, pulp, phosphorus and potassium chlorate industries in Japan, found in the very first issue of our contemporary. We shall now proceed to quote from Dr. Nishida's notes on other chemical and allied industries from later issues.

Cotton is grown in Japan, but owing to climatic conditions it is doubted if the plantations will ever reach the development of those in China, India and America. In Korea the acreage is increasing. The editor remarks that "its total area of the new plantation during 1916 were 249,236 acres, that makes total area of the cotton farm at Chosen as 303,886 acres. The crop from this total area corresponds to 50,266,400 lb." That would be a little above one hundred thousand bales, as we figure it. In Formosa they have struck oil, and it is claimed that "oil experts join that the petroleum vein at Formosa is quite hopeful."

The cement industry is thriving. Exports last year were 850,000 bbl., and this would have been a round million if shipping facilities had been better. The total production of cement is about 3,500,000 bbl. a year. In regard to textile fibers it is noted that silk and cotton are not the only dry goods of Nippon. Japanese hemp is of very high quality, but unfortunately it is also expensive. Flax is being cultivated in increasing measure, and the Japanese linen industry, as reported in our contemporary, "has acquired new hopeful footsteps and the flax plantation belongs to the most hopeful business." Of ramie, for which we thought the climate was too cold, we learn that "up to now its cultivation was not much cared, but recently, having found that South Japan is not unable for the purpose, the government has ordered to Miyazaki prefectural office to research on its practical plantation." We regard this as full of promise. Jute has succeeded in Formosa, but Manila hemp is given up as hopeless for climatic reasons.

Under the heading of Cattle Products it is observed that exports of feathers and leather were 228,000 yen (\$114,000), against imports of eggs, bone, bristle, butter, hides and leather of 8,321,000 yen (\$4,160,000). Of feathers and eggs as the products of cattle it may interest our readers to know that the exports of the former were 64,000, against imports of the latter of 509,000 yen. The figures on machine tools are interesting as showing the effect of the war. They are in yens (1 yen equals 50 cents):

Year	Imports	Exports
1913	27,000,000	8,000,000
1914	17,000,000	9,000,000
1915	7,000,000	23,000,000

We add comparative exports of a number of other articles for the same years, expressed in values in yen (1 yen equals 50 cents):

	1913	1914	1915
Medical instruments	155,000	345,000	870,000
Umbrellas and sticks	677,000	918,000	1,391,000
Boots	455,000	455,000	8,555,000
Toys	782,000	1,208,000	2,077,000
Glass	231,000	341,000	986,000
Electrical machinery	582,000	740,000	1,241,000
Stationery	278,000	479,000	1,300,000

One of the leading industries of the country is that of textile fabrics. According to statistics of 1913 the output of cotton goods was 165,377,234 yen, and of silk 120,326,546 yen, while the exports were 34,840,761 yen worth of cotton goods and 34,222,853 yen of silk. There are five well established and thorough textile colleges in the country.

These notes are taken only from what looks like the front, but really is the back of the journal. The rest is not even Greek to us. We wish it were. Then we should hark back to the memories of our youth and call in the next generation, now at work at that language, and, in happy consciousness of the man of Athens at the peanut stand on the corner of the avenue, feel that the contents might be revealed to us. But it is not Greek, it is Japanese, and to our shame we acknowledge that we are dumb. There are thousands of Japanese who speak English, and even if some of them strain the language a little, occasionally, in getting the ideas over, it doesn't do any harm. That is what language is for—getting ideas over. We, on the other hand, flounder about like fish out of water even before the title of the magazine. It looks like one word, but it may be four. There is a little t and a big T for one unit. The next is opposed E's with a double x between, on a roof over a 3 with a line through it. The next might be a cross section of an I beam, and the last a microphotographic reproduction of a section of a spider's web. But it doesn't mean anything to us; it only bewilders us. Glancing over the pages, we find three horizontal lines, a lean-to roof with two dots, a vertical line, an H gone wrong, a horizontal line, a scythe and a semaphore, and these, we are assured, signify bakelite. Soon after we strike bakelizer, and the only thing they seem to have in common is that roof with the dots. John Wesley Hyatt takes up nearly a column, but is composed of comparatively simple figures, whereas the Badische Anilin & Soda Fabrik looks like a map of Manhattan Island. We do not get ahead with our reading. Turning to the advertisements, there is a picture of a young man and a young woman of the plastered, flat-head, Tenderloin type sitting at a table drinking cocktails. Whether they are tourists or not we have no means of knowing, but we have not heretofore associated these, which are among the very least of God's blessings, as characteristic of Tokyo or any other part of Japan. We thought them almost indigenous to New York and Chicago. But there's no use in going on; we simply cannot make progress with the major part of the magazine. On the other hand, for that little which we can read, we are sincerely grateful.

Readers' Views and Comments

Aluminium Production of Canada

To the Editor of *Metallurgical & Chemical Engineering*

SIR:—In a table of "Production-Capacity for Aluminium" ("two or three years before the war"), published in your number of March 15 (page 329), Dr. Mailloux gives the capacity, in tons per year, of the aluminium plants in Canada as 2500.

I beg to draw attention to the fact that the Canadian Customs returns for the twelve months ending Dec. 31, 1916, give the "exports of aluminium in bars, blocks, etc.," as 9212 tons, besides a value of over \$26,000 for exports of "manufactured articles of aluminium."

As these figures are exports only, they would imply, I should judge, a much greater capacity of present output for the plant of the Northern Aluminium Company at Shawinigan Falls, as an appreciable quantity of aluminium is used in Canada.

THEO. C. DENIS.

A Fable It Will Seem in Years to Come

To the Editor of *Metallurgical & Chemical Engineering*

SIR:—The following verses were written by Edwin Markham, the author of "The Man with the Hoe," in honor of Alexander Graham Bell, the inventor of the telephone, and were read on the recent occasion of the presentation of The Civic Forum Medal of Honor for Distinguished Public Service to Mr. Bell:

ALEXANDER GRAHAM BELL

By Edwin Markham

Three wizards called the lightnings to their hands
And witched the world with wonder in all lands.
Morse, with a flower-touch, loosed the winged word
To ride the wires until the world's end heard.
Marconi shakes the ocean of the air,
And sends our words into the Everywhere.
But Bell flings off the cipher and the sign,
And with a cunning nearer the divine,
Lets out across the void man's living voice
To sorrow or rejoice,
Dispels the distances, shrinks up the spaces,
Brings back the voices and the vanished faces,
Holds men together tho the feet may roam,
Makes of each land a little friendly home!

The wires are everywhere,
The tingling nerves of the air.
Be-netting cities, speaking for all hearts,
From floor to floor their whispered lightning darts.
Looping the prairies, leaping hills and lakes,
Over the world their whispered lightning shakes.
They stitch the farms and link the battle-line:
They thread the Alps and down the Congo twine:
They throb among the Pyramids, and speak
Where Fujiyama lifts her perfect peak.

A fable it will seem in years to come:
How Bell gave speech to spaces that were dumb.
A fable it will seem:
He was one man, the one man with the dream.
When youth was on his brow,
He was a conscript burdened with a vow:
He was a man constrained
To seek a vision that the world disdained,
A vision that called laughers to the lips,
Laughters more stinging than the whistling whips.

"Wither the spaces, speak across the miles?"

How could the wise ones cover up their smiles!

"Send out our syllables like flying birds?"

How could the wise ones frame their scorn in words!

But now the deed is done,

And cried before the footsteps of the sun.

Honor the man whose gift from the All-God

Is shrinking earth into one neighborhood.

And so, great guest, magician of the voice,
We come to crown that gray head, and rejoice.

We gather here to-night

To glory a little in your life's long fight.

Take at our hands this humble wreath of praise

For all the toil and victory of your days.

Take this poor wreath: 'tis all we have to give

To those that nobly serve and nobly live.

What Mr. Markham says of Bell can be said with equal truth of many of our own chemical and metallurgical inventors. A fable it will seem in years to come.

I think Mr. Markham's poem deserves a place in the columns of your journal.

A. B. C.

Coming Meetings and Events

American Institute of Chemical Engineers, semi-annual meeting, Buffalo, June 20-22, 1917.

American Society for Testing Materials, Atlantic City, June 26-30, 1917.

American Chemical Society, Boston, Sept. 10-13, 1917.

Third National Exposition of Chemical Industries, Grand Central Palace, New York, week of Sept. 24, 1917.

American Institute of Metals and Foundrymen's Association, Boston, week of Sept. 24, 1917.

American Electrochemical Society, autumn meeting, Pittsburgh, Oct. 3-6, 1917.

American Institute of Mining Engineers, annual meeting, St. Louis, Oct. 8-13, 1917.

American Society for Testing Materials.—The twentieth annual meeting will be held at the Hotel Traymore, Atlantic City, N. J., June 26 to 29 inclusive. It is probable that means of assistance to the Government will be discussed. The president of the society has already forwarded a letter to President Wilson offering the services of the society and pointing out that the society might be useful in an advisory way in relation to specifications for materials and in a practical way in the inspection and testing of materials. A summary of the program follows:

Tuesday, June 26.—Business Meetings at 11 a. m., and 3 p. m. Presidential Address and Reception at 8 p. m.

Wednesday, June 27.—Business Meetings at 10 a. m. and 8 p. m.

Thursday, June 28.—Business Meetings at 10 a. m. and 8 p. m.

Friday, June 29.—Business Meetings at 10 a. m., 3 p. m. and 8 p. m.

Tuesday Evening.—Reception to members and guests.

Wednesday Afternoon.—Recreation period.

Thursday Afternoon.—Golf tournament.

Flotation Suit Decision of Appellate Court in Miami Case

On May 24, 1917, the Appellate Court in Philadelphia handed down its decision in the Minerals Separation vs. Miami Copper Co. infringement suit.

Judge Wooley wrote the majority opinion in which Judge MacPherson concurred. Judge Buffington, the presiding judge, handed down a dissenting minority opinion.

Judge Wooley, writing the majority opinion, places patentability upon the critical proportion of oil, the greater and different agitation resulting in a commercial froth. He holds that the agitation of the patent in suit is found first in the centrifugal pump, second in the break in circuit, third in the Pachuca tank. He does not find the agitation of the patent in the Callow cell.

He bases his conclusion upon the theory that no experiments were made in court in bubble tank or Callow cell without previous agitation in a Gabbett mixer or agitator, and says that the argument of the defendant is made upon the theory that its process consisted solely in passing thoroughly mixed, but quiescent pulp, directly into the Callow cell where it received its first and final aeration without previous agitation. He says that if the only agitation to which the pulp was subjected, after such agitation as in the prior art was necessary to mix the oil and ore, was the agitation of the Callow cell, he would not say that the agitation amounted to, or was the equivalent of the violent agitation of the patent disclosures and constituted infringement.

He continues that having used the process of the patent in the first three steps (the centrifugal pump—Pachuca, etc.), the defendant cannot escape infringement by taking an additional step, even though that step alone avoids the patent.

The majority of the court thus holds the first, second, and third patents valid and infringed.

Judge Buffington, in his minority opinion, declares no infringement, and agrees with the defendant's position that the agitation disclosed in the patent is a mechanical agitation, and that aeration is a distinctly different method.

* * *

While the majority decision thus appears to be strongly in favor of Minerals Separation, there are various interesting points which must be taken into consideration in connection with the decision.

The centrifugal pump referred to in Judge Wooley's majority opinion was a feature of the original *experimental* Callow plant at the Miami plant, but it seems that it does not form a part of the present *operating plant* of the Miami company. We also understand that although Pachuca tanks were installed in the operating Miami plant, they have not, however, been in operation since shortly after the flotation process was installed as a feature of the Miami operations.

It would seem to be a question, therefore, whether Judge Wooley's majority opinion, basing as he does the act of infringement upon the centrifugal pump and Pachuca tank, which are not features of present mill operations, is not, after all, a contingent opinion, and whether this, in conjunction with Judge Buffington's minority opinion, does not leave the whole question still inconclusive, necessitating still further unfortunate delay in reaching such adjudication as will definitely inform the mining public exactly where they stand in regard to the legal rights of the various flotation processes.

It seems not improbable that appeal will be taken

to the Supreme Court as a matter of right in view of the vast sums involved, and in view of the fact that the Appellate Court was divided, it is not unlikely that the U. S. Supreme Court will take the matter up for final adjudication.

Annual Meeting of American Iron and Steel Institute

The annual meeting of the American Iron and Steel Institute held at the Waldorf-Astoria Hotel in New York, Friday, May 25, was one of the best attended meetings ever held by the Institute. The grand ballroom of the hotel was almost filled when Judge E. H. GARY, president of the Institute, called the meeting to order at 10.15 a. m. Judge Gary made a splendid address in which he outlined the reasons for our entrance into the war and the part we must play owing to our great resources. His address will be found in full on page 634 of this issue.

Following this address, a paper on "Recent Installations of Large Turbo-Generators" was read by RICHARD H. RICE, of the General Electric Co. The paper was discussed by David S. Jacobus, advisory engineer of the Babcock & Wilcox Company, and Alex. Dow, president of the Detroit Edison Co.

The other paper of the morning session was read by ROBERT P. LAMONT, president of the American Steel Foundries Co., Chicago, Ill., on "The Manufacture of Steel Castings." Mr. Lamont traced the development of the steel-casting industry in Europe and America, particularly from the viewpoint of large steel castings. One of the greatest early difficulties in this country was in securing a proper molding sand. By 1887, however, a suitable mixture of sand and molasses had been obtained. Mr. Lamont said, in going over the history of the business during the period 1880 to 1890 one gets the impression that the castings were pushed on the market before the art was fully developed. Very few of the foundries had their own laboratories and the appearance of the castings was against them.

At the present time a very large percentage of all-steel castings produced in the country are used by the railroads.

"Of the approximately two million tons capacity of steel castings in the country to-day about 52 per cent is for basic and 48 per cent acid steel. Almost 90 per cent is produced in open-hearth furnaces, 8 per cent, the converter, and the balance crucible and electric. We have no accurate figures showing a division of tonnage as between dry and green sand molds, but the figures are probably not far from 60 per cent green sand and 40 per cent dry sand.

"During the past twenty years the development of the steel-casting industry has been steady and rapid, although, of course, the production has had ups and downs following general business conditions. Beginning with the nominal production of 1684 tons in 1883, by 1897 the production had increased to approximately 100,000 tons. To-day there are about two hundred steel foundries in the country, with a total rated capacity of approximately 2,000,000 tons, though the actual production given for last year was probably about 1,500,000 tons. The exact figures are not yet available. The production curve for steel castings for the past twenty years plotted alongside of one showing, for instance, the ingot production of the country shows a considerably more rapid rate of increase for steel castings.

"While the product cannot even yet be said to be perfect, a great deal of careful, painstaking, intelligent study has been given to overcoming the difficulties in the processes, and it can at least be said that steel castings have to a large extent lived down the somewhat uncertain reputation earned during the first development period.

"A comparatively recent important development in the industry was the coming in of the electric furnace. If it has not already done so, it will entirely replace crucibles and converters as a means of melting. Steel melted in the electric furnace can be brought to almost any state of purity desired, and a very high temperature can be se-

cured. The electric furnace will produce steel of as good quality and at lower cost than the crucible, assuming, of course, a reasonable price for current and sufficient demand to take the output of the furnace."

Mr. Lamont's paper was discussed by R. F. Flintermann, president of the Michigan Steel Castings Company, Detroit, Mich., who said it might be interesting to say something of the development of the small steel-castings industry, where castings are made having an average weight of 20 pounds. These have been made in the converter, crucible, and more recently in the electric furnace. Mr. Flintermann, speaking in favor of the electric furnace, said his company had a 6-ton and a 3-ton electric furnace, and that another will be installed. He said the electric steel castings were superior to crucible castings owing to the more complete deoxidation and the smaller amount of trouble with shrinkage cracks.

In the afternoon session papers were read by JOHN LYMAN COX, of the Midvale Steel Co., Philadelphia, Pa., on "Relative Merits of Forming Steel by Pressing, Hammering or Rolling," by WILLIAM O. SHERMAN, of the Carnegie Steel Co., on "Surgical Discoveries of the War," and by WALTHER MATHESIUS, superintendent of blast furnaces of the Illinois Steel Co., on "The Chemical Reactions of the Blast Furnace." The latter paper is published in full on page 636 of this issue.

In the evening the annual dinner was held at the Waldorf-Astoria. The principal speakers were George W. Perkins, who took as his subject "The Man of the Future," and John A. Topping, who spoke on "Co-operation and the Mobilization of Public Sentiment."

New York Section of Society of Chemical Industry

The last meeting of the season of the New York Section of the Society of Chemical Industry was held at the Chemists' Club on Friday evening, May 25. The chairman, Dr. JEROME ALEXANDER, presided.

A paper on "The Hat Industry of America" was presented by CHARLES D. PARKS, of Danbury, Conn. He said the hatting industry of America, according to the Government census of 1914, was conducted in 223 establishments producing 2,500,000 dozen hats, using approximately 6,000,000 lb. of fur and \$500,000 worth of chemicals and dyestuffs. Less than two per cent of the fur used in the industry is produced in this country. Mr. Parks explained the method of making felt hats and showed samples of hats in various stages of the process of manufacture. Chemicals have been used in increasing amounts in preparing the fur since the introduction of the forming machine in 1846. Quick-silver and nitric acid are used in preparing or corroting the fur. Shellac and alcohol are used in stiffening the felt for derby hats, and a large quantity of dyes is used in dyeing the material. Borax and soda are also used for cleaning stiffened felts.

Dr. A. C. LANGMUIR, of Brooklyn, N. Y., spoke on "The Outdoor Life of the Chemist." He said chemists should pursue some outdoor hobby such as geology, botany, etc., and he gave an intensely instructive and suggestive description illustrated with lantern slides of the many interesting things to be found in the vicinity of New York City.

Congress of Norwegian Engineers.—An informal congress and reunion of American and Canadian engineers and architects of Norwegian birth or descent will be held in Chicago at the Chicago Norske Klub, Sept. 27 to Sept. 29, 1917.

The Petroleum and Gasoline Situation*

By Van. H. Manning

Director of the U. S. Bureau of Mines

I am very glad to have the honor to be permitted to share in the patriotic endeavors of the Business Publishers and to bring before you, and through your public agencies, to the country, one of the, at least to my mind, serious problems confronting the United States at this time. I refer to the production and consumption of petroleum and gasoline in the United States.

Any remedy that can be applied to the petroleum and gasoline situation will come through conservation, which does not mean tying up, but a wiser use of what we have.

In the year 1916 there were 2,750,000 automobiles, or an increase over the year 1910 of 2,350,000.

The increased number of automobiles in 1916 used a billion more gallons of gasoline, or 28,000,000 barrels more, than the automobiles in 1910.

This increased use of gasoline for the increased number of automobiles alone represented a little more than half of the total output of gasoline in the country in 1916 for all purposes, the total production being about 54,000,000 barrels. And when you realize that the number of automobiles is increasing with each day, you can grasp what a tremendous problem is this feature alone.

The total gasoline engine horsepower built and sold in the United States in 1913, according to the Federal Trade Commission, was 11,200,000 and in 1915 the output had a little more than doubled, the figures being 22,500,000.

These figures indicate the increased use of gasoline power more clearly than those which cover only the automobiles, as these include all types of gasoline-driven machines which have been developed and increased in use in a way no less surprising than that of the automobile itself.

The apparently unsolvable puzzle about this is that while we have been increasing our production of gasoline, the production of automobiles has increased 200 per cent above the increase in gasoline production. These are the facts that we must face. Where is it going to end?

Statistics indicate that of the gasoline produced in the United States, between 55 per cent and 60 per cent is used in the automobiles of the country, 20 per cent to 25 per cent is exported, and the balance is used in stationary engines, in motor boats, tractors and for various purposes of minor importance.

As the highways of the country are improved, the commercial trucks, consuming large quantities of motor fuel, are becoming important means of transportation in many localities. The fishing fleets of our entire coasts have installed gasoline power to replace their original sailing equipment. These fleets, with the many pleasure craft, operated mostly in the summer months, when the production of gasoline is most heavily taxed, use large quantities of this convenient liquid fuel. There seems no reason to believe that the call for gasoline will in any way be reduced; in fact, a much larger demand seems imminent.

As the production of gasoline depends upon our supply of petroleum, let us look to the source and see what we find. Petroleum and its products have become essential to our very existence. Gasoline is a very important product, but there are many others. The operation of hydroelectric generators, of railway and trolley cars, of the machinery of the factories, of internal combustion engines, of our battleships and our merchant

*Address delivered before the Editorial Conference of the Business Publishers Association, Washington, May 25, 1917.

ships, in fact, of all machinery, is made possible by the use of lubricating oils, and these come from petroleum. Petroleum lubricates the machinery of the nation from the handicraft of the watchmaker to the dreadnought of the navy.

The industry has progressed since its beginning a little over half a century ago, when it was possible to store the entire production in tin cans and wooden barrels, to the present, when the annual quantity produced requires great steel, concrete and earthen reservoirs for its storage, great pipe lines for its transportation and fleets of specially constructed vessels for its exportation.

In discussing briefly the supply and demand for petroleum in this country for the last few years, permit me to say that the stored reserve of petroleum is the most stabilizing influence in the industry. I wish also to bring out the fact that during the last few months our increased consumption has made it necessary to draw oil from this storage, which has convinced many people that our present supply has reached a point where it may never again be sufficient to fill easily the demand placed upon it, unless some radical steps are taken to conserve its use. One of these steps frequently mentioned, and one that is slowly dawning upon our consciousness, is that the burning of crude petroleum under boilers for the generation of steam ought to be stopped. In this way large quantities of priceless by-products are being consumed.

In the year 1916, the marketed production of crude petroleum was, according to the estimate of the United States Geological Survey, 295,000,000 barrels. The stocks held by various pipe-line and transportation companies at the end of January, 1916, according to various trade journals, amounted to approximately 175,000,000 barrels; at the end of 1916 the stocks amounted to 150,000,000 barrels, which represents a decline of 20,000,000 barrels, even in the face of our greatest annual marketed production of 295,000,000 barrels.

If consumption of crude petroleum exceeds production, the difference must be drawn from storage. The question that naturally presents itself here is what of the future? During 1915 the normal consumption of crude petroleum was 12 per cent greater than in 1914, and last year our consumption exceeded the 1915 consumption by 13 per cent. Estimating that the normal peace consumption for this year will increase at the same rate, or 13 per cent, our consumption for 1917 will exceed that for 1916 by about 40,000,000 barrels. This does not take into consideration the increased demand for petroleum and its products due to the entrance of this country into the war. Although this increased demand because of the war is difficult to estimate, obviously the increased use for various war purposes will greatly enlarge our consumption above the rate which prevailed during times of peace. The production of crude petroleum in this country during last year is thought to have reached high-water mark, and it is very likely that the production for 1917 will be smaller than it was last year. If the normal and war demands for petroleum can be filled, the difference between the estimated production and consumption during this year will amount to probably as much as 60,000,000 barrels, an amount which must be drawn out of storage. With only about 150,000,000 barrels of crude petroleum in storage at the first of this year, and with the prospects of it becoming necessary to draw from that reserve probably 60,000,000 barrels to fill that demand, it becomes more apparent that some radical steps must be taken to meet the situation.

We should not pass over the situation with an optimistic statement that when the time comes new fields

will be discovered, as has happened in the past, or that new methods will be found whereby this threatened shortage will be overcome. We should undertake to anticipate this problem as best we can, for we certainly will encounter it in the not distant future.

While the present increase in the number of pleasure cars may not continue, it is plain that the use of gasoline for power in many commercial fields has not yet fully developed, and as this use widens it will more than overcome any falling off in the rate of consumption of gasoline in the cars used for personal purposes, if such falling off should occur.

The fact we must face is that the production of petroleum is not increasing as rapidly as the production and consumption of gasoline. The petroleum in time will reach its maximum production and start to decline. What we are doing now is looking to more efficient methods of production from the oil sands, the production of more gasoline by the so-called cracking process, the extraction of vapors from natural gas, and the utilization of liquid fuels from other than petroleum bases.

More efficient methods of production are now being developed, such as the Smith-Dunn process for forcing oil from the sand with air or gas under pressure.

The cracking of petroleum last year furnished 7½ per cent of the total gasoline production and can be and is being developed and installed rapidly in most of the larger fields of the United States. Its possibilities are enormous.

The treatment of natural gas by compression, refrigeration and absorption produced 60,000,000 gallons of gasoline of such low boiling point that it was mixed with equal parts of naphtha to form 120,000,000 gallons of good motor fuel. The compression and refrigeration process of extracting gasoline from natural gas, when first used, treated only gases containing three gallons or more of condensable vapors per 1000 cu. ft., but at the present time the development of the process and the increased price of the product make gas carrying one gallon profitable. The extraction of gasoline from gases containing less than one gallon and as small a quantity as one pint per 1000 cu. ft. is now being profitably carried on by the absorption process, which is well adapted to treating lean gases in large volumes. Another source of petroleum which will undoubtedly be developed in time is the shales containing considerable quantities of oil but which, at present prices of crude oil, cannot be extracted commercially.

Substitutes for gasoline, such as the products of the distillation of coal, are being used at present in Europe for motor fuels, and may in time be used for that purpose in this country, as many by-product coke ovens are now being constructed.

Bureau of Standards Analyzed Samples

The Bureau of Standards, Washington, D. C., now has ready for distribution its high-phosphorus standard analyzed Iron E No. 7, which is typical of the irons from the Alabama area. The analysis is carbon 2.17, graphite 1.82, combined carbon 0.38, silicon 2.21, titanium 0.095, phosphorus 0.862, sulphur 0.051, manganese 0.444, copper 0.021, chromium 0.014, nickel 0.016, and vanadium 0.073. The renewal, No. 12b, of the basic open-hearth steel approximately 0.4, carbon, is also ready. Until printed certificates can be secured the above samples will be issued with provisional certificates without details of analysis or description of methods. A new sample of Bessemer steel with approximately 0.1 per cent carbon to replace No. 8a is now in process of analysis.

The Western Metallurgical Field

Ore Dressing

Some Uses of Magnetic Separators.—The use of a series of magnets of different strengths makes it possible to separate materials having different magnetic permeabilities and also to separate magnetic from the non-magnetic ores or concentrates. In treating monazite sands magnetite is removed by the weakest magnet, ilmenite by the intermediate and the monazite by the strongest. The non-magnetic material passes away, giving three concentrated products. Magnetic separators of the multiple-pole type have found application in the dressing of zinc ores. Marmatite, a ferruginous sphalerite, is slightly magnetic, and is separated from the raw pyrite by the most powerful magnet. Non-magnetic zinc-iron sulphide ores require a slight roast to make the pyrite magnetic and the separation of these two constituents is accomplished by the low strength magnets. Franklinite, fowlerite and garnets are separated from willemite, zincite, quartz, mica and calcite by means of such machines.

The literature regarding the magnetic separation of tungsten ores from other ores is somewhat scant. Some tests along these lines have been made, but opinions seem to be at variance with one another. In the Nederland District in Colorado magnetic separation is not in use as yet. On the other hand, magnetic separation seems to be in use in several of the other tungsten camps in the United States. It is absolutely essential that the concentrates obtained from tungsten mills be high grade and uniform in composition. The magnetic tungsten minerals, wolframite, huebnerite and ferberite lend themselves particularly well to treatment by the magnetic separator according to some authorities. In the wet concentration of tungsten ores, the heavy sulphides of iron, lead, zinc, etc., as well as the heavy oxides of tin, magnetic iron, arsenical sulphides, carbonate of lead, garnets and other impurities pass off the tables and contaminate the tungsten concentrates. The multipolar magnetic separator completely eliminates these detrimental minerals. Again there is no market for a mixed product of tungsten and tin, or for wolframite and scheelite mixed, as each of these latter minerals requires a different method for the extraction of the tungstic acid. By passing the combined wolframite-scheelite concentrates over the magnetic separator, the wolframite is removed by the magnets, while the non-magnetic scheelite passes off at the end of the machine.

Magnetic separation is also possible for the following: the separation of pyrrhotite from other sulphides, garnet or gangue; of roasted chalcopyrite from garnet and epidote; of roasted chalcopyrite from iron or nickel sulphides; of magnetite from weakly magnetic minerals; roasted limonite from smithsonite and calamine; pyrolusite from quartz gangue; leucite from lava; magnetite from corundum; magnetite, menaccanite, chromite and pyrrhotite from diamond-bearing concentrates; magnetic galena (probably iron-bearing) from zinc ore and gangue and finally hematite from gangue minerals.

Company Reports

Tenth Annual Report of the Nevada Consolidated Copper Co.—The total tonnage of ore milled during 1916 was 3,922,634 tons, averaging 1.632 per cent copper, with an actual mill extraction of 73.87 per cent, the ratio of concentration being 7.45 and the average copper in the concentrates 8.98 per cent. The total milling costs for the year were 55.9 cents per ton as against 53.3 cents for the year 1915. In addition to the tonnage treated as mentioned, the Consolidated

Coppermines shipped 50,911 tons of 1.593 per cent ore to the mill. This was concentrated and the resultant product smelted under toll contract.

During the year many improvements at the concentrator have been made, both for the purpose of increased tonnage and improved recoveries. The Huntington and the Chilian mills were replaced by the tube mills. A considerable number of double-deck tables and other apparatus were installed for the purpose of increasing the concentrating capacity. As the old coarse crushing department of the concentrator is inadequate for the present plan of milling 14,000 tons of ore per day, a new coarse crushing plant was started in July, 1916. It is anticipated that this new unit will be in operation on June 1, 1917.

The eighteen furnaces, initially used in the roaster department, were remodeled to aid in increasing the capacity. Four new furnaces were added to the plant during the course of the year, and the necessary changes in the flue connections were completed. In the smelter department, plans are being considered whereby oil fuel is to be replaced by powdered coal in the reverberatory furnaces. This change is made necessary due to the increased cost of fuel oil and the inability to obtain satisfactory supplies after the expiration of the present contracts.

Increasing the daily capacity necessitated several changes at the power plant. A 20,000 cu. ft. per minute steam-driven turbo-blower was installed to supplement the blowing engine in supplying air for converters and other purposes. A 2000-cu. ft., two-stage, steam-driven air compressor was installed as an auxiliary to the high-pressure air system required for shop work, and a 3000-kw. turbo generator was ordered to cover the power demands of the concentrator, in line with the increased mill tonnage contemplated.

The production of refined copper resultant from the year's operations was 90,735,287 lb. as compared with 62,726,651 lb. for the year 1915. The net operating cost per pound of copper produced was 9.44 cents. Miscellaneous earnings for the year amounted to 1.31 cents per pound, which, if deducted from the actual operating cost, will leave a final net cost of 8.13 cents per pound.

Military Census of New York City's Factories and Mercantile Establishments

New York State proposes to take a census and inventory of the military resources of the State under laws passed this year and the State Military Law. A director of the census has been appointed for each county and one for the city of New York. Mr. E. P. Goodrich, member of the American Society of Civil Engineers, has been given the latter post. A preliminary enumeration has shown that in Greater New York there are about 3200 factories and mercantile establishments in which are employed 400,000 persons, or more than 10 per cent of the estimated total military population of the State. It was believed that this large group of persons could be readily segregated and returns secured from them in their places of employment.

Director Goodrich has asked Mr. Alfred D. Flinn, member of the American Society of Civil Engineers, to organize a volunteer force from among the engineers of the various branches of the profession in New York City, to take this part of the census. It is estimated that 400 or more engineer canvassers will be needed, each giving two full days or more of his time. Letters giving further information and forwarding pledge cards will be sent to the engineers of New York City in the very near future. If any of our readers are able to

help and do not receive such an invitation, they may communicate with Director Goodrich or Mr. Flinn at 261 Broadway, Room 904.

Personnel of Council of National Defense and Its Advisory Commission

Committees and Sub-Committees

The Council of National Defense, at the head of which are the Secretaries of War, Navy, Interior, Agriculture, Commerce and Labor, has an Advisory Commission composed of the following seven members:

Daniel Willard, president Baltimore & Ohio Railroad.
Howard E. Coffin, member American Society of Mechanical Engineers, vice-president Hudson Motor Car Company.

Dr. Hollis Godfrey, member American Society of Mechanical Engineers, president of the Drexel Institute.

Julius Rosenwald, president Sears, Roebuck & Company.

Samuel Gompers, president American Federation of Labor.

Bernard M. Baruch, financier.

Dr. Franklin H. Martin, surgeon.

The members of the Advisory Commission serve in a consulting capacity without compensation.

The Council and Advisory Commission were authorized by Congress, Aug. 29, 1916, and have been very active in mobilizing the industries of the country for war. The headquarters are in the Munsey Building, Washington, D. C. Walter S. Gifford is director and Grosvenor B. Clarkson secretary of the Council and Advisory Commission. Many committees and sub-committees have been formed composed of representative men in the various industrial fields. The chief committees are as follows:

Transportation, including railroad and motor transportation, and Communication, Daniel Willard, chairman.

Munitions, manufacturing, including standardization and industrial relations, Howard E. Coffin, chairman.

Raw Materials, minerals and metals, Bernard M. Baruch, chairman.

Labor, including conservation of health and welfare of workers, Samuel Gompers, chairman.

Supplies, clothing, etc., Julius Rosenwald, chairman.

Science and Research, including engineering and education, Hollis Godfrey, chairman; Henry E. Crampton, vice-chairman.

Medicine, including general sanitation, Franklin H. Martin, chairman.

Under Raw Materials, sub-committees have been formed with chairmen as follows: General chemicals, William H. Nichols; fertilizer, Horace Bowker; alkalis, J. D. Penstock; acids, E. H. Grasselli; miscellaneous chemicals, Edward Mallinckrodt, Jr.; cement, John E. Morrow; alcohol, Horatio S. Reubens; aluminium, Arthur V. Davis; asbestos, Thomas F. Manville; brass, Charles F. Brooker; coal tar products, Wm. H. Childs; lumber, R. H. Downman; lead, Clinton H. Crane; mica, L. W. Kingsley; nickel, Ambrose Monell; oil, A. C. Bedford; rubber, H. S. Hotchkiss; steel, Elbert H. Gary; sulphur, Henry Whiton; wool, Jacob F. Brown; zinc, Edgar Palmer; copper, John D. Ryan.

The complete membership list of several of the sub-committees is as follows:

Copper.—John D. Ryan, president Anaconda Copper Company; Murry Guggenheim of M. Guggenheim Sons, New York; R. L. Agassiz, president of the Calumet-Huerta Mining Company, Boston; C. M. McNeils, president of the Utah Copper Company, New York; James

McLean, vice-president of the Phelps-Dodge Corporation of New York, and W. A. Clark, president of the United Verde Copper Company of New York.

Zinc.—Edgar Palmer, New Jersey Zinc Company, New York; Charles W. Baker, president American Zinc, Lead & Smelting Company, New York; A. P. Cobb, vice-president New Jersey Zinc Company, New York; Sidney J. Jennings, vice-president United States Smelting, Refining & Mining Company, New York; Cornelius F. Kelly, vice-president Anaconda Copper Company, New York; N. Bruce MacKellvie, president Butte & Superior Copper Company, New York; Thomas F. Noon, president Illinois Zinc Company, Peru, Ill.; Chas. E. Orr, president Bertha A. Mining Company, Webb City, Mo.

Lead.—Clinton H. Crane, president St. Joseph Lead Company, New York; Fred W. Bradley, president Bunker Hill & Sullivan Mining & Concentrating Company, San Francisco; Edward Brush, vice-president American Smelting & Refining Company, New York; E. J. Cornish, vice-president National Lead Company, New York; Harry L. Day, Hercules Mining Company, Burke, Idaho; F. Y. Robertson, vice-president and general manager U. S. Metals Refining Company, New York.

Aluminium.—Arthur V. Davis, president Aluminum Company of America, Pittsburgh; E. E. Allyn, president Aluminum Castings Company, Cleveland; Jos. A. Janney, Jr., Morris Building, Philadelphia.

General Chemical Committee.—William H. Nichols, chairman; Van H. Manning, director Bureau of Mines, and C. A. Richards, U. S. Department of Commerce; J. D. Cameron Bradley, secretary; E. R. Grasselli, Henry Howard, William H. Childs, Horace Bowker, Charles H. MacDowell, Edward Mallinckrodt, Jr., and J. D. Penstock.

Fertilizer.—Horace Bowker, chairman; Charles H. MacDowell, Charles F. Burroughs, Porter Fleming, W. D. Huntington, William Prescott, Frederick Rayfield and Charles G. Wilson.

Coal-Tar By-products.—W. H. Childs, chairman; J. A. Topping, H. H. S. Handy, C. J. Rainsburg, W. H. Gartley, W. R. Addicks and W. E. McKay.

Alkalis.—J. D. Penstock, chairman; J. D. Ford and C. H. MacDowell.

Acids.—E. H. Grasselli, chairman; Henry Howard, C. Wilbur Miller, J. M. Goetchius and Mr. Cooke.

Miscellaneous Chemicals.—Edward Mallinckrodt, Jr., chairman; George P. Adamson and Adolph G. Rosengarten.

Alcohol.—Horatio S. Reubens, chairman; Julius Kessler, Carman M. Smith.

Oil.—A. C. Bedford, chairman; G. S. Davison, E. L. Doheny, E. C. Lufkin, John H. Markham, Harry F. Sinclair, J. W. Vandyke.

Cement.—John E. Morrow, chairman; B. F. Affleck, George T. Cameron, Richard Hardy, E. M. Young.

The general chemical committee has established headquarters at Washington in charge of Dr. Wm. H. Nichols, who is devoting all of his time to this work. The committee is co-operating with the Bureau of Mines, the U. S. Geological Survey and the Bureau of Soils in various problems, and all chemical problems are first submitted to this committee. The Manufacturing Chemists' Association of the United States and the National Fertilizer Association have also established offices in Washington in the Woodward Building.

Electrochemists Supporting the Government

The American Electrochemical Society, through its board of directors, has voted to invest \$2,000 from cash in hand in Liberty Bonds—an example which, we hope, will be followed by other scientific and engineering societies.

Presidential Address to the American Iron and Steel Institute

By Elbert H. Gary

Presented at New York City on May 25, 1917

THE UNITED STATES DID NOT SEEK WAR

The people of the United States constitute a peace-loving nation. They abhor war and would go, have gone, great lengths to avoid it. They are considerate, reasonable and forbearing. They are not envious of their national neighbors. They neither seek nor desire anything that belongs to any other country. If they had an advantage over other nations, in any department of human endeavor, they would not unjustly profit by it. Their ambition is to cultivate good will and friendship and their hope is to avoid enmities. Their consistent purpose and effort have been to occupy an independent position among nations, unentangled and uncomplicated with alliances or associations that might interrupt the policy of aiding and never antagonizing others.

These observations are based on history. The record has been written and cannot be changed by any who may impugn the motives or conduct of our people. Such a citizenship when driven to self-defense by a barbarous despotism is apt to be the most terrible, even though civilized and human in its combativeness. This country is largely made up of men and women who came here to live in peace and tranquillity, or the descendants of such; they wish to progress and prosper as the result of privileges which the exclusion of war always permits. The great majority, if not the total, of our inhabitants appreciate what our Republic, with its protective institutions and manifold opportunities, means to every citizen, and with noble impulses they will in every emergency rally around and follow the Stars and Stripes, their emblem of honor, of liberty and of justice.

We did not desire, we persistently and consistently sought to avoid, trouble with Germany and her allies. We had always been the true friends of the Teutons until the ruling powers, for reasons not comprehended by us, forced us into the position of self-defense. We believed, as indeed it was admitted by the invaders, that they were reckless, lawless and cruel in their treatment of their neutral and unoffending neighbors, but as a nation we refrained from interference or even criticism. As human beings we suffered intensely as we learned of the outrages perpetrated upon the innocent victims of force and brutality; and still our nation, not for lack of sympathy, but rather on legal grounds, stood aloof. We were neither indifferent nor selfish, but our President, after full and careful consideration of all the facts and the construction of the rules of international law as determined by the best legal talent, decided he was obligated to remain silent and inactive. For one, I think his conclusions were warranted.

Even after the Central Powers trespassed upon the well-established rights of the persons and property of individual American citizens, our Government was patient and unmoved to action, accepting the excuses and promises of the aggressors. As a nation we exercised more restraint than any large and powerful people ever before practised under provocation so great. Our chief executive indulged the hope for long and weary and suffering days that our entry into the pending war might be avoided. The wish was father to the thought, and this sentiment filled the minds of the majority of the people of the United States.

At last war was forced upon us. The President was compelled to conclude that we were intentionally attacked, that the honor and integrity of our country could no longer be maintained unless the gage of battle

was accepted; and in this decision he was supported by the whole country. His clear, powerful, convincing and eloquent statement of the case and impeachment of the enemy will stand out in history as one of the greatest official declarations and also as fully justified by the existing facts and circumstances.

A COLOSSAL UNDERTAKING

But we have entered upon a colossal undertaking, justified only by the necessities of the case and on the highest moral grounds. It is doubtful if any of us fully realizes the strength of the enemy, even though we know his grim determination. His numbers, his preparedness, resources, devices, creative ability, methods, protective barriers, means of rapid mobilization and transfer of troops and supplies, are further advanced in effectiveness than any other army or armies have ever been. This concentration and perfection of the utilities of military strength should not be underrated. Years of steady, active and studious, though secret, effort have brought about the creation of a giant, powerful, remorseless, conscienceless; and up to the present this kind of a government, armed to this extent, seems to have an abiding conviction that it can overcome all opposition and sooner or later pursue a war of aggression and conquest.

RIGHT MAKES MIGHT VS. MIGHT MAKES RIGHT

And yet, the Allies possess an element of strength not appreciated—if it could under any circumstances be understood—by those who are in control of the armies of the Central Powers. The Allies are contending that Right makes Might; their enemies that Might makes Right. We are of the opinion that we possess a weapon that must prove all powerful. With this as the foundation and inspiration of our armies they are better able to utilize all the forces at their command. It will require time, skill, numbers, sacrifices and large sums of money; but nothing that we do not possess in abundance. For the reason that we are right and the enemy is wrong, we shall probably see other nations of strength and importance, now neutral in attitude, join the Allies, if the war shall be protracted. Some or all of the South and Central American republics, China, Spain, Scandinavia, Holland and Switzerland ought to come in and probably will before the Central Powers are allowed to accomplish what they attempt. These countries could not afford to permit their people to become subject to the dominance of a nation which considers force as the only consideration for aggression and expansion.

With the unprecedented and increasing wealth and the vast resources of the United States she is able to assist materially in providing the financial necessities for equipping multitudes of soldiers from other countries; and if necessary, all these must be mobilized in the defense of a common and righteous cause. And as to equipment, the brains of the Allies, ourselves included, will, in time, be sufficient to match and overmatch the best talent that is possessed by our adversaries after many years of constant thought and study. Among other things it is conceivable that if the Allies had the best and most effective types of aircraft, outnumbering those of the other side five or ten to one, they could obtain and hold control of the air and in this way destroy the productive works, transports of troops and supplies, storage warehouses and other facilities for offensive and defensive warfare of the enemy, and thus materially increase the advantage now held by reason of numbers and resources. We may be sure our experts are giving due consideration to all the possibilities for improved machines and methods.

WHAT WE ARE FIGHTING FOR

What are we fighting for? This question is asked and answered, in one form or another, by millions of people. I give an answer that seems to me to underlie all others: We are fighting to firmly establish and permanently maintain a basis whereby every international question in dispute must be determined in accordance with the principles of justice.

To bring this about, other questions which are obvious, must be determined; but if the above-mentioned basis is secured everything else necessary will have been or will be disposed of.

ALL SHOULD BE WILLING TO SACRIFICE

The task which confronts the country is not confined to the army and navy, although they will be entitled to the larger part of the credit and glory if we succeed. They offer their bodies as a sacrifice, and they must have the undivided, unqualified support of all outside their ranks. The time, money and prayers of all civilians must be given for the soldiers. They bear the brunt; they are the shield for our safety. All of us are fighting in self-defense. This is our land and the flag is ours. The administrators of the country, from President Wilson down, are no more interested than each of us. Life would not be worth living if our flag were to be permanently furled; if our country were subjugated by an alien enemy, especially such a one as we now defend ourselves against.

The pecuniary burdens to be imposed upon us will be very great. We knew in advance such would be the case. We must pay the enormous cost of mobilizing, equipping, supplying and moving our own armies; and we must advance money and provide supplies to our Allies in accordance with their necessities and our resources. We could not decline if we were disposed, for they are now fighting our battles and we are, with them, under the whole burden. We must never falter nor retrace our steps. Wherever or whenever the end is we must press forward with all our strength, might, minds and souls. The more vigorously we proceed within the limits of intelligence, the sooner will the end be reached.

EQUITABLE DISTRIBUTION OF TAX BURDENS

Some of us are complaining or criticising because of the enormous taxes that are likely to be imposed. We are apt to consider ourselves as opposed by the legislative or executive departments of the Government, as if they were partisans, seeking to punish or at least unfairly treat the private individual. We do ourselves an injustice by harboring such thoughts. We can rightfully claim that the burden of taxation be equitably distributed; that all the people, after exempting the necessities of life, shall be compelled to contribute; and that there shall be no waste or extravagance in making expenditures. If possible, taxes ought to be so levied and distributed as to avoid clogging the channels of business prosperity. All this we may properly demand. Equitable distribution is fair and reasonable, and it makes all pecuniarily interested in the subject, including both the collection and the expenditure of the taxes levied. Less than this would tend to create classes—the worst thing for any country.

Now is the time to unite the whole country in a common cause. The soldiers are on a level as they ought to be. All others should be on a level. Classes should be obliterated and also politics, localities and religious differences during war times at least. Opportunity should be open to all; governmental burdens should be borne by all. With such an administration of governmental affairs we should be satisfied, however

severe the drafts which are made upon us or upon the larger interests which we represent.

I lately spent a few days in Washington, and it was my privilege to meet a number of men who in legislative halls or executive departments are serving their country; and it is certain that all are actuated by the motive to fairly represent and protect the best interests of the country and all the people. Individuals are not influenced by politics. There are and will be differences of opinion concerning the various questions presented, as a matter of course, but these will be adjusted and the legislation finally passed will represent an honest endeavor to do what is proper.

GOVERNMENT IS CO-OPERATING WITH BUSINESS

You have heard some criticism concerning the conduct of the Government's business affairs. It has been said that confusion or at least lack of system or co-operation sometimes appears; but it must be remembered that there has been suddenly thrust upon the Government officials an enormous amount of business, extraordinary in volume and character, and the strength and capacity of all are taxed to the utmost and often beyond physical endurance. Besides, rules of law or of departments established to fit other conditions sometimes appear and prevent the exercise of judgment which would bring better results if more latitude were permitted. Officials in Washington are entitled to credit and praise for their management under existing circumstances, and so far I believe there is no just ground for severe criticism.

And then there is a disposition on the part of Government officials to co-operate with the business men in promoting the welfare of the country. This is what all of us have desired and advocated, and now we will probably have as much opportunity in this direction as we have ever desired. Just what will be the result in all the ramifications of the business involved remains to be seen. To the extent that the directors of this Institute have been personally connected with these matters they have been well satisfied, except perhaps as to some of the prices in question.

Mr. B. M. Baruch, chairman Committee on Raw Materials, Minerals and Metals of the Advisory Commission of the Council of National Defense, writing for himself and the Secretary of War, and also representing the Secretary of the Navy, requested your president to act as chairman and to appoint other members of a committee on Steel and Steel Products, to co-operate with the Government; whereupon the matter was brought before the directors of this Institute and such a committee was designated, consisting of the following: Elbert H. Gary, chairman; James A. Farrell, vice-chairman; James A. Burden, E. A. S. Clarke, Alva C. Dinkey, Willis L. King, Charles M. Schwab, John A. Topping.

The general committee has appointed sub-committees as follows:

For Ascertaining Capacities and Supervising Allotments of Orders to Manufacturers.—James A. Farrell, E. A. S. Clarke, J. A. Topping, E. H. Gary, ex-officio.

On Alloys.—J. A. Farrell, E. A. S. Clarke, A. A. Fowler, E. G. Grace, E. J. Lavino, E. H. Gary, ex-officio.

On Iron Ore, Pig Iron and Transportation.—H. G. Dalton, Frank Richards, Harry Coulby, George T. Dyer, W. T. Shepard, A. H. Woodward, Leonard Peckitt, Frank Billings, Amos Mather, secretary.

On Sheet Steel.—W. S. Horner, Charles Hadley, Walter Carroll.

On Scrap Iron and Steel.—Eli Joseph, Samuel Deutsch, Vernon Phillips, Joseph Michaels.

On Pig Tin.—John Hughes, E. R. Crawford, Edwin Groves.

On Tin Plate.—J. I. Andrews, E. R. Crawford, E. T. Weir.

On Tubular Products.—James A. Campbell, chairman; other members to be appointed. Possibly other committees.

The committees meet regularly and are devoting much time to the work involved.

They have, with other work, been engaged in mobilizing the resources of the different producers of steel, such as the Government requires for its purposes, and the statistics are in the possession of the secretary of this Institute.

The Secretary of the Navy submitted a program for 1917 for plates, structural shapes and bars needed for ships, and after considerable negotiation contracts were closed in behalf of the producers on the basis of \$2.90 for plates and \$2.50 for structural shapes and bars. We were of the opinion that in view of present costs and other conditions we should receive larger prices, but in the spirit I have referred to the proposition of the Government was accepted. As costs of production are advancing on account of increases in wages, taxes, prices of certain raw materials, etc., it is expected the Government will be willing to increase its purchasing prices accordingly.

IRON AND STEEL FRATERNITY PATRIOTIC

The Iron and Steel fraternity, represented by this Institute, will be actuated by the highest conception of patriotic duty with respect to the requirements of the Government. We will cheerfully bear our full share of the load which must be carried until there is realized a complete triumph over the hosts of aggressive, desperate and inhuman autocracy. Personal interests will yield to the necessities of the country we love.

Chemical Reactions of Iron Smelting*

By Walther Mathesius

Superintendent of Blast Furnaces, Illinois Steel Company

Throughout the Middle Ages, and as late as the first half of the nineteenth century, blast furnaces were operated the world over with the utmost secrecy. Those skilled in the art carefully guarded their knowledge, surrounding their work with a veil of mystery and handing it down from father to son as a precious tradition.

The first attempt of science to invade this magic circle was, as far as I know, made by Robert Bunsen, who, in 1839, investigated the operation of a little charcoal furnace in connection with his fundamental work on the development of methods for analyzing gases. Since then experimental and operating data relating to the blast furnace process have become available in goodly numbers and a multitude of theories have been advanced, based on such information. In many instances, theories have also been advocated which unfortunately did not have the foundation of such actual experience. In this way volumes have been written, but by far the largest portion of these efforts have been of an explanatory nature, exploring into features of operation which had previously become established through practical experience. Thus it may be stated that, up to the present day, the operating man is still leading in the race between the blast furnace theory and practice, and it need not surprise, therefore, that even to-day blast furnace theorists are being looked

upon by some practical men with a certain lack of esteem.

There are still many adherents to the creed that blast furnace progress must be brought about through practice, leaving it to science to afterward explain the "whys and wherefores." Men of this type overlook the fact that, since the introduction of hot blast, when explanations were sadly lacking for the startling improvement wrought thereby, science has made gigantic strides to close the gap between actual results and their theoretical understanding. The existence of this gap has afforded in the past splendid opportunities for harassing the blast furnace with schemes the futility of which, while theoretically apparent, still had to be proved and paid for by failure in practice. So, as the day draws near when the scientist will wring from the blast furnace its last mystery and will mark it down with mathematical exactness, the theory of the blast furnace process demands of the furnace operator more respect and attention than ever before. While he may not care to follow all the intricate lanes of research and experimentation that have led to the present knowledge, he should have a thorough understanding of the process with which he deals, and it is from his standpoint that I intend to review the reactions of iron smelting as carried on in the blast furnace of to-day.

The task of the blast furnace, while performed as one continuous and interlocking process, may be divided into physical and chemical duties. Among the former the principal items are:

(A) The drying and preheating of the burden materials.

(B) The melting and superheating of the resultant iron and slag.

The chemical duties comprise chiefly the following:

(C) The calcination of the carbonates.

(D) The reduction of the metallic oxides of the ore burden.

The relative importance of the physical and chemical work may be best judged by comparing the amount of energy consumed by each. This can readily be calculated by establishing a heat balance.

An average taken from a number of such calculations covering modern operations shows that, of the total heat introduced into a blast furnace and generated therein, approximately 25 per cent is sufficient to take care of the above-mentioned physical duties, while the chemical reactions require about 60 per cent of the total, the balance being absorbed in radiation losses and heat escaping with the gases. These figures gain particular interest when considering that it is the physical part of the blast furnace work only that is immediately accessible to observation and measurement. It will also be readily understood that any improvement or deterioration in the chemical work must affect the furnace efficiency as a whole to more than double the extent than would a change of equal magnitude in the physical or melting operation. Economy in the performance of the chemical reactions is, therefore, of prime importance to the blast furnace man.

By far the largest part of the blast furnace chemical work consists of the reduction from the ores of the various constituents forming the pig iron. The reducing agent, to bring about this transformation, is furnished by the fuel. From the total amount of coke which is charged into the blast furnace, a certain percentage is always carried out by the furnace gases as coke dust, and another portion is dissolved by the pig iron. At plants using similar raw materials, and under normal operating conditions, the sum of these two items varies only within narrow limits and amounts to a small percentage of the total. It does not decidedly

*A paper read before the American Iron and Steel Institute at New York City on May 25, 1917.

influence the general efficiency of the furnace operation, for which the fuel consumption is the most generally accepted criterion. The latter depends almost exclusively on the mode of gasification and utilization of the remaining major portion of the carbon in the coke. The possibilities in this respect are:

1. The carbon, having passed downward through the furnace stack, reaches the hearth and is gasified there either by:

(a) Combining with the oxygen of the blast at the tuyeres, or

(b) Combining with the oxygen of metallic oxides (direct reduction).

2. The carbon does not reach the hearth, but is gasified above the hearth by reacting with the CO_2 of the furnace gases (premature combustion).

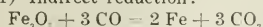
The reactions classed under 1 are normal operating necessities. The reaction (a) creates heat and reducing gas (CO); the reaction (b), while consuming heat, furnishes reducing gas and pig iron product. As long as their sum total and their relative proportion remain within proper limits, these reactions must be classed as desirable, while an excess of either one is superfluous and detrimental.

The reaction named under 2 produces, at a loss of heat, reducing gas only, which, if at all required in the operation of the furnace, could be more advantageously furnished by either reaction 1(a) or 1(b). The premature combustion of carbon must, therefore, in all cases be considered a detrimental reaction.

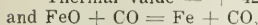
All three of these reactions have one thing in common. They produce carbon-monoxide, the agent by means of which by far the largest portion of the metallic oxides in the furnace burden is reduced to metal. This process, for which the equation $\text{Fe}_2\text{O}_3 + 3\text{CO} = 2\text{Fe} + 3\text{CO}_2$ may serve as an example, is known as "indirect reduction." Its economy is in a large measure responsible for the remarkable efficiency of the blast furnace, which to the present day has not been surpassed by any other metallurgical process.

To substantiate this statement, and to answer several arguments brought forth lately disputing the superior efficiency of the "indirect" over "direct" reduction, the following comparison should be made:

(1) Indirect reduction:

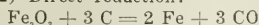


Thermal value = + 426 b.t.u. per lb. of carbon.

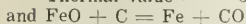


Thermal value = + 351 b.t.u. per lb. of carbon.

(2) Direct reduction:



Thermal value = - 5406 b.t.u. per lb. of carbon.

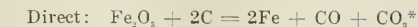
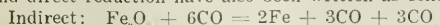


Thermal value = - 5481 b.t.u. per lb. of carbon.

(Thermo-chemical data from J. W. Richards' "Metallurgical Calculations.")

It can readily be seen that, from the thermo-chemical standpoint, the indirect reduction, showing a slight gain of heat, is decidedly superior in efficiency to the direct reduction, with its very material loss of heat. But also with reference to carbon consumption, the indirect reduction has the advantage. While, for the same amount of iron reduced, the carbon requirement is the same in both cases, the indirect reduction utilizes carbon in the form of CO , while the direct reduction consumes carbon, which could be used to better advantage for the generation of heat by burning it to CO with the oxygen of the blast at the tuyeres.

The equations illustrating the comparison of indirect and direct reduction have also been written as follows:



and on the basis thereof it has been stated that, as regards carbon consumption, "direct" reduction was three times as efficient as "indirect" reduction. The errors of this line of reasoning are obvious. There are three molecules of CO introduced into the first equation which are by no means essential for the carrying on of the reaction, in which they are taking no part. The second equation shows as one of the products of the direct reduction, carbon dioxide, which cannot possibly exist in the presence of carbon at temperatures necessary for the direct reduction. Even if carbon dioxide were momentarily produced, it would instantaneously be converted back into carbon monoxide, and in doing so require the additional molecule of carbon, which thus is actually consumed in the process of direct reduction.

Thus it is evident that, from a standpoint of economy, the indirect reduction is more desirable than the direct reduction. The latter is economically permissible only under the following conditions: First, where indirect reduction cannot take place—for instance, when oxides to be reduced are not accessible to furnace gases; and, second, in case the combustion of carbon by the oxygen of the blast at the tuyeres does not furnish sufficient carbon monoxide with which to properly take care of the indirect reduction.

Direct reduction, as mentioned first, takes place in every furnace and is a function of the composition of the iron; in other words, the percentage of silicon, phosphorus, manganese, etc., to be reduced and of the percentage of burden materials, the metallic contents of which are for physical or chemical reasons not affected by the reducing action of the furnace gases. With these conditions given, this phase of direct reduction can be considered as practically constant.

The other case of direct reduction, which is due to scarcity of CO from combustion at the tuyeres, is most likely to be incurred where furnaces are burdened with ores that are easily reduced, and where such furnaces are operated at a fast rate of driving, with high-blast temperatures. Under such conditions, direct reduction will take place to a greater extent the lower the percentage of silicon is in the pig iron. Modern Mesaba practice on basic iron is a good example.

The possibility of a deficiency of reducing gases under the conditions mentioned has frequently been disputed; the chief argument brought forth has been that in furnaces of this class the ratio of CO_2 to CO in the top gases is almost without exception considerably lower; or, in other words, the top gases have a greater reducing power than appears necessary according to the well-known curves of equilibrium as established by Baur and Glaesner. While this is true, it should not be overlooked that the data used as basis for these curves are the results of laboratory experiments with sufficient time allowed for any and all reactions to run through to completion.

Comparing, on the other hand, the volume of gases generated at the tuyeres per minute with the cubic contents of the furnace, and considering at the same time that the stack is not empty but filled to the top with ore, stone and coke, that therefore the only spaces available for the furnace gases are the voids between the solid particles, it is apparent that the time during which the volume of blast entering through the tuyeres can possibly remain in contact with the furnace burden is, at best, only a few seconds. This short interval is all that is available for each molecule of gas to undergo the various reactions which take place between the oxygen of the blast or ore and the carbon of the coke,

*J. W. Richards, "Metallurgical Calculations," pages 252, 253.

between the resultant CO and the metallic oxides of the ore and between carbon dioxide and the carbon.

It is evident, therefore, that the extent to which the various reactions will perform within the blast furnace depends to a large measure upon the reacting speed of which they are capable. The speed of any chemical reaction decreases the closer the relative quantities of the reacting and resulting substances approach the status of equilibrium. Therefore, the various reactions cited above will, within the limited time available in the blast furnace, take place to a larger extent the farther away the relative quantities remain from the status of equilibrium. In other words, in order to be reducing to a degree sufficient for actual practice, the furnace gases must be richer in CO than would be expected from the experimentally determined diagram of Baur and Glaesner.

Thus the possibility of a modern furnace being insufficiently supplied with carbon monoxide through the combustion of carbon at the tuyeres is by no means remote. It is incurred particularly where, with easily reduced ores, high blast temperatures are used, because with higher blast heat the generation of the necessary quantity of heat in the hearth requires less carbon. Theoretically, and keeping strictly within the boundaries of Gruner's theory of the ideal working of a blast furnace, this condition should be remedied by lowering the blast temperature and burning more carbon at the tuyeres. Otherwise, ore must reach the hearth without being properly reduced by the gases, there to be reduced by solid carbon, with a consequent loss of heat to the hearth.

In modern practice this question is solved differently and more economically by permitting direct reduction to take place and at the same time offsetting the entailing heat loss by raising the blast temperature. The limit to which this direct reduction can be carried on depends on the ability to offset the resultant heat deficit in the hearth by higher blast temperature, and on the necessity to keep the top temperature above the desired minimum which is essential for the timely drying and preheating of the ore charges preparatory to their reduction by the furnace gases.

The results obtained may briefly be summed up as follows: Without raising the volume of wind blown, the amount of carbon gasified in the hearth and the weight of metallic oxides reduced per unit of time is increased. The furnace operates at a higher rate of output without requiring additional coke for its hearth reactions. As the cooling and radiation losses per ton of iron are inversely proportional to the rate of production, a saving is effected in this respect, which must ultimately find its expression in a lower coke consumption. As part of the coke carbon is gasified by oxygen from the ore without the addition of nitrogen from the blast, the amount of gas per unit of burden material charged becomes less. The initial temperature of the gas leaving the hearth not being changed, this results in a lower top temperature as well as a lower temperature of the stack. The beneficial effect of this drop in stack temperature on coke consumption and on furnace practice in general will be dealt with later.

Incidentally it may be said that this line of reasoning offers a very plausible explanation for the quite frequently observed fact that in Mesaba furnaces, where high blast heats are available, the burdening of certain percentages of materials not affected by the reducing influence of the furnace gases, such as sinter, results in benefits as mentioned.

Being an endothermic reaction, all direct reduction has frequently been considered detrimental. In reality this can apply only to an excess of direct reduction be-

yond the limits as outlined above. From the same point of view, direct reduction in the hearth has often been confused with direct reduction in the stack, which more correctly should be termed "premature combustion." The latter consumes coke carbon before it reaches the hearth by attacking it and dissolving it in carbon dioxide in the upper regions of the furnace according to the equation $\text{CO}_2 + \text{C} = 2\text{CO}$.

Its influence on the furnace efficiency, both thermal and with reference to carbon consumption, is the same as that of excess direct reduction in the hearth. My previous statement concerning its detrimental character is true the more as in practice premature combustion takes place at the highest rate when any addition to the carbon monoxide content of the gases is least desired.

At temperatures below 900 deg. to 1000 deg. C., premature combustion does not take place to any appreciable extent, as can readily be seen from the curves of equilibrium established by Bondouard. Since its reacting speed grows rapidly with rising temperatures, it is evident that premature combustion must take place in the furnace stack at an increasing rate the higher the temperature of the zone in which the carbon dioxide and the coke come into mutual contact and the longer they remain in contact with each other at temperatures above 900 deg. C.; that is, generally speaking, the higher the average stack temperature of the furnace happens to be. Thus it occurs to a large extent in furnaces making high silicon iron, or furnaces operating on a highly refractory burden, for instance, of magnetite ores. Under such conditions, carbon monoxide is produced over and above the already existing abundance, which has resulted from extensive direct reduction, and which cannot be used to any advantage in the furnace.

In furnaces producing low silicon iron and operating on an easily reduced ore burden, premature combustion may also assume serious proportions, where the rate of driving is too slow and the time is thus unduly prolonged during which carbon dioxide remains within the regions of high temperature in contact with coke. The apparently logical means of counteracting this condition is "faster driving." In many cases this can only be practised after a change in the quality of coke has been brought about.

I refer especially to the combustibility of the coke, the importance of which was first emphasized and termed by Mr. H. A. Brassert in his paper on "Modern American Blast Furnace Practice," read before this Institute in May, 1914. This quality, above all, determines the pace at which a furnace can be operated. Unfortunately, a change of coke structure which tends to improve its combustibility will in many instances simultaneously increase its vulnerability to the solving action of the gases, so that the benefit reached on the one side may be more or less offset by the deterioration wrought in the other direction.

However, modern American coke-oven practice has made enormous strides toward approaching the apparently paradoxical ideal of a coke which with the highest rate of combustibility would combine immunity from solution in furnace gases. This is accomplished by producing coke with an open-cell structure in which the cell walls themselves are amply strong and well protected by a graphitic coating. The results accomplished in this respect are in a large measure responsible for the remarkable improvement of coke practice which has been obtained at a good number of American blast-furnace plants during recent years.

Among the ways and means which counteract premature combustion and are practised aside from faster

driving, I wish to mention one which is now so universally used that its value is often overlooked. I refer to the use of raw limestone as flux. Realizing that it took a considerable amount of heat to calcine the stone, and in an effort to relieve the blast furnace of this duty, the attempt was repeatedly made in past days to charge burned lime in the place of raw stone, but without attaining the expected improvement.

The explanation lies obviously in the fact that the endothermic calcination of the limestone, which takes place about 900 deg. C., is one of the most effective means to quickly bring about a cooling of the furnace gases below the zone of temperature where premature combustion can take place; it appears that thereby, and by simultaneously preventing premature fusion of the ores, which would place the latter beyond the reach of indirect reduction, more coke is preserved and made available for the generation of heat at the tuyeres than is necessary to furnish the heat required for the calcination of the stone.

Since the direct reduction, where practiced within economical limits, increases the ratio of burden to furnace gases, thereby lowering the average stack temperature, it, too, may be termed an effective antidote against premature combustion.

Another most effective means of preventing premature combustion is the application of high blast temperatures. By thus accelerating combustion at the tuyeres, providing for the heat requirements of the hearth with less fuel and a consequently lower volume of gases, concentrating the zone of highest temperature and increasing the ratio of descending materials to rising gases, a decided lowering of the average stack temperature, with correspondingly better fuel economy, can be and has been accomplished. For instance, the blast furnaces at South Works, Illinois Steel Company, being operated according to these principles, have for a number of years, in spite of a severe handicap in the form of irregular coke supply, not for a single month exceeded a coke consumption of 1900 pounds per ton of iron for twenty-one consecutive months. During the year 1916 these same furnaces, with an average age of 331,771 tons per lining, produced 2,066,256 tons of iron on an average coke consumption of 1854 pounds per ton.

From the analysis of the various reactions, it is evident that direct reduction and premature combustion in reference to origin, performance and prevention are two distinctly and entirely different processes, each one independently playing its own important part, in widely varying degrees, in every furnace operation. The only common tie between them is their endothermic character and the fact that they both consume carbon. The sum-total of their carbon consumption represents what is usually called the amount of carbon gasified above the tuyeres. As this carbon is consumed partly by economical and partly by wasteful reactions in ever-varying proportions, it is evident that the relation of this total "carbon gasified above the tuyeres" to the fuel consumption of a furnace cannot possibly have a direct bearing on the economy of operation.

These relations have until quite recently remained obscure, because it was considered impossible to separately calculate direct reduction and premature combustion, while their combined total could be obtained with comparative ease by either subtracting the weight of the carbon gasified at the tuyeres from the total carbon gasified in the furnace, or by directly using the following mathematically developed and therefore universally applicable formula:¹

$$C_x = \frac{3}{4}O_c - \frac{7m}{11 + 7m}(C - C_{F_c}) + \frac{11}{11 + 7m}C_{C_z}$$

in which

C_x means the amount of carbon gasified above the tuyeres,

O_c the oxygen contained in the metallic oxides of the burden,

m the ratio by weight of CO_2 to CO in the top gases,

C the total weight of carbon charged,

C_{F_c} the weight of carbon absorbed by the pig iron, and

C_{C_z} the carbon contained in the CO_2 of burden and flux.

To cite in detail the method of dissecting this " C_x " into its constituents, direct reduction and premature combustion, is beyond the scope of this paper. Suffice it to say that it is done by establishing separate balance sheets for the hearth and stack with reference to heat as well as materials, and therefrom determining the theoretical top temperature for varying percentages of the two constituent reactions involved.² The light which this method of calculation is able to throw upon the economics of furnace operations would seem to justify the belief that it is the solution for the most complicated of blast-furnace puzzles.

To complete this review of blast-furnace reactions, I wish to mention one which in modern furnaces appears only occasionally to any extended degree. This is the decomposition of carbon monoxide according to the equation $2CO = C + CO_2$.

As the speed of this reaction is comparatively low, on account of the existing ratio of quantities involved, and since the zone of temperatures within which it can take place is limited to approximately from 400 deg. to 600 deg. C., the extent of this reaction is, as a rule, slight. Theoretically it must be classed as economical, being exactly the reverse from "premature combustion." However, in practice, when this reaction takes place to any considerable degree, serious difficulties are encountered which make it extremely undesirable. The resulting carbon is deposited on the ores in a very finely divided form and interferes with their permeability to the gases, clogging the voids and causing a swelling of the charges, scaffold formation and all the serious troubles which follow.

When fine Mesaba ores were first used in larger percentages, such difficulties due to excessive carbon deposition were experienced more frequently. With furnace lines poorly suited for the smelting of these fine ores, particularly with the flat bosh angles then in use, irregular working of the furnace with protracted periods of hanging were nothing exceptional. The movement of the furnace charges being brought to a standstill for considerable periods of time, a much larger percentage of the materials in the upper part of the furnace stack was heated to a temperature where decomposition of carbon monoxide could take place, with a corresponding increase in the extent of this reaction as the result. Since then, however, furnace lines have been improved to such an extent as to make operating difficulties from this source a rare exception in Mesaba practice.

It has been observed, too, that a high percentage of hydrogen is often present when carbon is deposited in this manner. The reducing power of hydrogen relative to that of carbon monoxide increases with falling temperatures, and it is reasoned that, with a high percentage of the former, metallic iron in finely divided form is reduced from the ores at exceptionally low temperatures; this metallic iron then acts as a catalytic

¹Professor W. Mathesius, "Investigations Concerning the Blast Furnace Process," ("Untersuchungen über die Vorgänge in Hochofen"), Stahl und Eisen, 1913, page 1467.

²Professor W. Mathesius, "Die physikalischen und chemischen Grundlagen des Eisenhüttenwesens," Spamer, publisher, Leipzig, Germany, 1916.

agent which greatly increases the reacting speed of the decomposition of carbon monoxide.

Excessive hydrogen in the top gases to an extent necessary to bring about such a condition is generally the result of defective apparatus, such as leaky hot-blast valves, tuyeres and bosh plates. If this be the case, the undesirable deposition of carbon can be overcome by removing the source of the hydrogen.

From the standpoint of an operating man, I have attempted to give a brief outline of a subject about which volumes have been written by men of science without ever covering the field. To them belongs the task of further theoretical exploration. We blast-furnace operators must be ready to apply and prove in practice.

Illinois Steel Co.,
South Chicago, Ill.

Buffalo Meeting of American Institute of Chemical Engineers

The ninth semi-annual meeting of the American Institute of Chemical Engineers will be held in Buffalo, N. Y., from Wednesday, June 20, to Friday, June 22, inclusive. Headquarters will be at the Hotel Statler. An interesting technical program has been prepared and part of the time will be spent in excursions. All of the business and technical sessions will be held in the Hotel Statler.

A special program has been prepared for the ladies who will also accompany the men on the automobile trip Wednesday afternoon and on the excursions Thursday and Friday afternoon. The program follows:

WEDNESDAY, JUNE 20, 1917

9.30 a. m.—Address of Welcome. David C. Howard, first vice-president Buffalo Chamber of Commerce.

Business Session.

11.30 a. m.—Reading of Papers. "Some Machinery Employed in the Manufacture of Glue," A. Lowenstein. "Treatment of Sewage by Aeration in the Presence of Activated Sludge III," Edward Bartow.

12.30 p. m.—Luncheon.

1.30 p. m.—Automobile trip around the city and inspection of the Buffalo Foundry & Machine Company.

6.30 p. m.—Dinner.

8.00 p. m.—Reading of Papers: "The Manufacture of Linseed Oil," Glenn H. Pickard. "Trade Wastes Disposal," H. P. Eddy.

THURSDAY, JUNE 21, 1917

All day at Buffalo Canoe Club.

10.15 a. m.—Take excursion steamer from the foot of Commercial Street to Crystal Beach, Ontario. Transfer at the beach to launch "Marion L" arriving at Buffalo Canoe Club about 11.30.

12.30 p. m.—Luncheon. The afternoon to be spent sailing in Abino Bay, swimming, canoeing, playing tennis or taking some of the beautiful walks up through Point Abino.

4.10 p. m.—Leave on launch "Marion L" for Crystal Beach.

4.30 p. m.—Take steamer for Buffalo.

7.00 p. m.—Joint subscription dinner at Hotel Statler for the Buffalo Engineering Society and the American Institute of Chemical Engineers. Addresses by F. A. Lidbury, president of the Buffalo Engineering Society, and President G. W. Thompson of the American Institute of Chemical Engineers.

FRIDAY, JUNE 22, 1917

9.00 a. m.—Business session.

10.00 a. m.—Reading of papers: "Symposium on Potash." "A New Method of Potash Recovery from Feldspar," Prof. J. C. W. Frazer and Dr. E. Miller. "Potash from Waste Liquor of Beet Sugar Factories," H. E. Zitkowski. "The Possibilities of Developing an American Potash Industry," R. K. Meade.

12.30 p. m.—Luncheon.

1.30 p. m.—Automobile ride to Niagara Falls.

3.30 p. m.—Take car for ride around the Great Scenic Gorge Route.

5.00 p. m.—Leave Niagara Falls for Buffalo.

6.30 p. m.—Dinner.

8.00 p. m.—Reading of Papers "Chemical Engineering Aspect of Renovating a Sulphide Mill," H. K. Moore. "Waste Heat Utilization," H. D. Baylor.

American Gear Manufacturers Association Convention

The recently organized American Gear Manufacturers Association held its first convention at the Hotel Schenley, Pittsburgh, Pa., on May 14 and 15, 1917. An interesting program was arranged and elaborate preparations made by the Pittsburgh members for entertaining the visiting manufacturers.

The association has been organized for the purpose of developing, standardizing and improving all products of the gear industry. In view of the present national situation this convention will undoubtedly have a very important bearing on the efforts being put forth by the Government for absolute standardization in all lines of manufacture. The personnel of the membership comprises men who, by reason of the fact that they represent companies making one of the most important items used in automobile construction, may well be said to have been the means of placing the automobile industry in its present pre-eminent position.

The officers of the association are: F. W. Sinram, Van Dorn & Dutton Company, Cleveland, president; H. E. Eberhardt, Newark Gear Cutting Machine Company, Newark, N. J., vice-president; F. D. Hamlin, Earle Gear & Machine Company, Philadelphia, secretary, and Frank Horsburgh, Horsburgh & Scott, Cleveland, treasurer.

The convention was opened Monday, May 14, by F. W. Sinram, president, and the morning devoted to an executive session. In the afternoon S. L. Nicholson, sales manager of the Westinghouse Electric & Mfg. Company, spoke on "The Ins and Outs of an Industrial Organization," and James E. Gleason presented a paper on "The Spiral or Curved Tooth Bevel Gear." On the following morning papers were presented by Frank Burgess on "Job Gearing—To What Extent Can It Be Standardized?" and by William Ganschow on "Advantages of Gear Standardization." In the afternoon George L. Markland discussed the "Difficulties of Gear Standardization."

The entertainment features included an informal dinner at the Hotel Schenley, followed by dancing, automobile trips and a theater party for the ladies, and a bowling contest at the Pittsburgh Athletic Association.

On Tuesday afternoon the delegates visited the works of the Westinghouse Electric & Mfg. Company at East Pittsburgh, Pa., where they witnessed methods of manufacturing bakelite micarta for gears, after which they were the guests of the Westinghouse Company at a dinner in the club rooms of the Pittsburgh Athletic Association.

The Call for the Chemist*

Experiences of the Employment Bureau of the New York Chemists' Club

By Prof. Herbert R. Moody

College of the City of New York

Only the merest fragment of the employment work of the country goes through the Bureau of the Chemists' Club, but it is felt that that fragment is an "aliquot part" of the whole, and hence is an indicator of the trend of demand and of increases or decreases in general or in special lines.

The field of the chemist has developed rapidly. When many of us were graduated, twenty or more years ago, it was the exceptional factory that had a staff of chemists, or even one chemist. When taken through factories, as a student, I recall that I rarely saw more than the crudest sort of control laboratory, and it was fitted with not even all necessities, let alone refinements. Such laboratories as those at the Grasselli Works, the Barrett Company, and the Corn Products Company, to say nothing of such magnificent ones as those of the General Electric Company, were not even dreamed of.

One of our lately deceased college professors told me that the head of one of our greatest industries came to him, certainly not twenty-five years ago, and in course of conversation said that he was disturbed because he had such great quantities of alcohol left from experiments in development work, and that he had no idea how to purify it and use it over again. The impurity being non-volatile, the professor had no difficulty in telling him that it could be purified by distilling the alcohol away from the impurity. "Do you mean to say," said the manufacturer, "that you can sit here in this office and tell me that certain things will happen if you work in a certain way?" "Certainly," said the professor. "Well," said the manufacturer, "if it proves to be as you say I will always run my factory on scientific lines hereafter, and control my work with a staff of chemists." Naturally, it did work as the professor said, and a German was at once imported to establish a control laboratory; and at the time he left, a few years later, I was engaged to take his place as soon as I was graduated. Chance led me, instead, in the following few months, into the teaching profession, but as I was graduated in 1892 the incident is not wholly ancient history. The case is perhaps a little unusual, but it certainly was not unique. You would be amazed if I divulged the name of the company, for it is now one of the greatest industries in the State, even in the country, and it supplies the world with its commodities. The popular mind in those days had not conceived of control chemists, and classed the whole lot of us in with pharmacists, or at best as workers of results far removed from the necessities of ordinary business.

I need go no further with the development of years up to 1913. You are all familiar with the accomplished fact of the acceptance of the chemist as a by no means humble cog in the industrial wheel, but recent years have been unusual, and hence of exceptional interest.

"No conscientious reporter can yet say," writes Mr. Wm. Hard in a recent magazine article, discussing social changes due to the war in Europe, "whether it is the greatest war of history by reason of being the most destructive and desolating, or the greatest war of history by reason of being the most creative and fruitful." This is a new view to take of war. Is it possible that there can be liberalizing influences at work that take their inspiration from a condition in itself the very antithesis of tolerance and liberalism? This is a ques-

tion worth keeping before us in any consideration of the relation of this country to the struggle in Europe.

But certain it is that the chemical industries have responded to the impulse. No need for me to rehearse to this group the increase in volume of old processes and the establishment of processes entirely new (at least in this country). To maintain these processes, research and control men have been needed, and the result has been that chemistry has become a more desirable and lucrative profession. The colleges have felt the urge, and classes have often doubled, sometimes quadrupled, so the increased demand is easily met by the new supply.

The chemist with special training has resulted in the establishment and rapid growth of the club's employment bureau. Formerly handled almost entirely by the chairman of the club committee in his own office, it has in a few years come to occupy two offices upstairs, and requires the entire time of four efficient young women to the ability of whom the writer takes this occasion to bear testimony. The work being only an avocation to him, without such intelligent helpers he never could have established nor maintained such a standard as has been reached.

The club's committee represents the bureau in Lowell, Brooklyn, Niagara Falls, Pittsburgh, Savannah, St. Louis, Denver, Chicago and Los Angeles. Thus our aid is secured by employers and employees in most of the great centers. We could, however, handle more calls than we receive, and all employers here present will do us a favor if they will let us know their needs. The increase in geographical scope of the work of the bureau is most interesting. While a large part of our calls are naturally from the metropolitan district, yet we are in receipt of calls from all over the world. We even hear from such unlikely places as Siberia, and other parts of Asia, South America, Mexico and Europe. We have recently placed a man in the Dutch East Indies.

Of course, calls from such places, although carrying excellent salaries, are hard to fill, since very specialized qualifications are insisted upon. The bureau is in great need of a far longer list of specialists. It hopes that any of this audience, even though they may in no sense "be looking for a position," who are specialists in any line will record such specialty with the bureau. It may prove to be of great advantage to all concerned. This tremendous increase in the call for the man with special experience is one of the features of the present expansion. Daily we are obliged to hopelessly reply that we have no man with such experience on our lists. There must be such men in the country, and we wish that you would let us know what your specialties are. A call for you may not come at once, but when it does we need you badly. Such calls are often for consultation only, and could be handled in addition to the man's regular work. Figures showing the increase in calls for men specializing in work which could be classed as "organic" are interesting. Calls for inorganic men remain rather constant, but in four years the organic men have come to receive three times as many calls. From 1913 to 1916, inorganic calls were 161, 98, 149, 136, whereas for the same years organic calls were 46, 65, 141, 158. As said at the beginning, bureau calls, of course, represent only a minute fraction of the vacancies of the country, but it is felt that changes shown by them are representative of the country. Therefore, the following may be taken as showing the immensely greater demand for men of our profession. I have taken the last four years as illustration.

In 1913 we had calls for	275 chemists
In 1914 we had calls for	358 chemists
In 1915 we had calls for	707 chemists
In 1916 we had calls for	841 chemists

*A paper read before the New York Section of the American Chemical Society, May 11, 1917.

If only at the same rate as the first four months of this year (1917) we shall exceed the figure for 1916. Undoubtedly, in light of present events, the call will increase in the remaining eight months. The bureau is able to provide satisfactory candidates for about 50 per cent of the positions reported to it. It could raise this percentage well on toward 75 per cent if more specialists would register. It is with greatest difficulty that we find men to take positions involving works control with heavy acids, wood products, coke-oven by-products, textiles, dyes, rubber, soap, uncommon pharmaceuticals, perfumes, essential oils, storage and dry batteries, electrochemical products, hydrogen peroxide, etc., etc. We would be glad to know of men trained and experienced in all these lines.

The following table gives interesting figures showing the increase in calls:

	1913	1914	1915	1916
Laboratory	189	179	407	481
Works	39	70	142	162
Research	18	26	36	44
Teaching	24	35	52	23
Stenographers	5	3	6	3
Salesmen	4	8	6	11
Advertising men	1	0	0	1
Translators	6	4	3	3
Miscellaneous	5	13	24	18

It is oftentimes supposed by those unfamiliar with the work of the bureau that calls for good salaried positions are infrequent. To such persons the following tables are of interest.

	1913	1914	1915	1916
Calls at salaries under \$700	26	47	65	54
From \$700 to \$900	62	44	100	103
From 900 to 1,200	82	93	198	125
From 1,200 to 1,500	56	77	128	145
From 1,500 to 2,000	44	71	120	126
From 2,000 to 3,000	13	15	46	63
From 3,000 upwards	1	3	17	17

In this table is also shown the *increase* of higher salaried positions.

Tables showing calls for chemists would not be complete if reference were not made to calls for women. Since woman in industry has become an assured fact it is interesting to see if the woman chemist increases in numbers as fast as those in other professions. It certainly seems as if she did not. There is a distinct prejudice to hiring women in works laboratories, and the bureau rarely places one there. It is a prejudice which will surely be overcome, and ought to be overcome faster than it probably will be. The supply is fairly constant, and is growing, and will grow faster if at all encouraged. The bureau is constantly in receipt of letters from individuals, women's chemistry clubs at colleges, and from the colleges themselves, asking what the outlook for the woman chemist is, and whether we advise the emphasizing of such work for their girls.

My personal experience is that women for laboratory work are the equal of men, and in many cases show superior qualities of neatness and order, regularity of work, and freedom from distraction from duty. We always urge their employment wherever the isolation of the factory or the class of men employed in the works does not make the presence of women undesirable. Nearly every factory has women in its offices, however, so there is usually no reason why they should not be in its laboratories.

The bureau figures on the subject are as follows. Attention is called to the great discrepancy between the number of places which women *could* fill and in which we *did* place them.

	Total Calls	For Women Only	Men or Women Work	Not in Laboratory Placed
1913-1914	643	15	7	9
1915	707	6	7	10
1916	772	10	6	5

Generally everyone thinks at once of dye work and work on explosives if he begins to picture the increase in chemical industry. I have, therefore, taken a few facts and figures regarding these two industries which trace development.

The height of demand in explosives work (beginning in 1914) came in the winter of 1915. The calls came from new companies or old ones enlarging their works. The demand has slackened to a very large extent. Many of the men who took these positions thought it was an industry about to contract in volume and so have left for more permanent lines of work. Calls now are mostly to fill the vacancies caused by the departure of these men. Of course, the recent declaration of war in this country has changed this situation, but its effect has not yet been felt in the Bureau. The height of the demand for men in the dye industry was felt in winter of 1915, having reached its maximum quicker than that of the explosives industry, since we had no calls for dye men during 1914.

Calls in these industries varied since routine men were asked for in the explosives even from the start. In the dye work, however, the calls at first were entirely for highest-grade men, specially trained in this work. There were practically no such men available, and although \$5,000 up was offered there were no possible candidates. These specialists were non-existent in 1914 and had to be developed. The demand was for men "with experience," generally specified as "with experience in this line in Germany." Since such men did not materialize, substitutes have been found in men of foreign training experienced in organic pharmaceuticals or in textile dyeing industry.

It was noticeable that the demand was at both extremes and little "in the middle." That is, it was either \$5,000-up men or \$720-\$1,800 men. There was little chance for men good in other lines, but who had not this special experience and yet who had commanded salaries of \$2,000-\$3,000. That is, a large number of college instructors, etc., who thought there was a great opportunity for organic research along such lines, and who desired to make the change, found no opportunity calls come in. There was a time in those two years when manufacturers were throwing money into such developments with the hope of large returns and wanted men who could at once, with no experimentation, build and operate these unusual plants. This period was followed by one demanding groups of six or eight or more to do routine and research. Then this stage was followed by one in which contracts expired or companies went to the wall for one reason or another, until to-day the companies still existent are fairly stable, although evidence is not lacking of internal crumbling in some of them. At the present minute they are apparently not enlarging, and calls are only to fill changes in personnel.

It is interesting to note the increase of metallurgical work. Both in Canada and in the United States we note increased calls in this field. These are mostly along routine lines, but a marked upward movement in iron, steel, brass and copper is observed. No increase has come in calls from electro-metallurgical plants nor electrolytic industries.

The trend toward industry is shown in the teaching profession. Not only are young as well as seasoned instructors leaving or hoping to leave teaching work, but this year's graduates will not look at a teaching offer. Even a teaching fellowship does not interest him.

This unrest is noticeable not only in the ranks of teachers, but is seen in those already in industry. Everyone seems to think it is "a good time to change," and is looking for big results "somewhere else." We are besieged with requests for change of position.

Lastly, the most interesting phase is the increased idea of value of service held by so many of our men. Two years ago many of our men thought they were doing very well with the salary they received and prospects of increase. Now, as previously said, most of them are "looking for something better." A typical case is that of a man only ten months out of college who was getting \$120 a month in a position in which we placed him. He has just written in that he is to leave and wants a higher paid position. It seems as if the high salaries paid in munition and dye works account for this feeling even more than the increased cost of living. Even raw graduates expect far greater salaries at the start of their careers. Two years ago \$55 to \$60 was considered by the men as a reasonable starting salary; now they state \$80 to \$90 as their minimum. Even non-graduates, just Sophomores and Juniors, expect to get \$75 for their half-trained services.

As the concluding evidence of growth or perhaps lack of growth, in one direction let me give figures regarding plants which we have observed now to employ chemists which have not previously found their services necessary: This figure astounded me, as I supposed investigation would prove it to be a far larger one. It seems to be the case, however, that previous to present development nearly all manufacturers already employed chemists or that present development has affected only such previously established industries as were already progressive enough to employ modern control methods. Be the reason one or the other, it is true that out of 1200 positions reported to us in fifteen months just passed, but five came from employers who were established previous to 1915 and yet who had never before engaged chemists.

The Cracking of Petroleum in the Liquid Phase*

By Roy Cross

In the study of the temperature-pressure decomposition relations of the hydrocarbons composing petroleum, it is necessary to confine all substances in a closed vessel with the vapor in equilibrium with the liquid in order to observe the conditions under which transformations take place.

In the application of heat to such a system it is most convenient to apply this heat to the liquid phase. In so doing, the temperature of the oil and the pressure developed are correct indices of the vaporizations and transformations within the system.

The amount of pressure developed up to a certain point is directly proportional to the temperature. At this certain point, however, the pressure is no longer proportional to the temperature, but increases at a much greater rate than the increase of temperature and the pressure under certain conditions even continues to rise with no increase in temperature and with an actual fall of temperature.

The rate of development of pressure depends upon the actual temperature of the confined oil, and also depends upon the character of the oil under treatment.

The certain temperature at which the disproportionate rise of pressure takes place is not absolutely definite, as it seems to be much lower when the rate of heating is low and much faster with a high rate of heating or a high temperature of oil.

In fact, if the temperature of the oil is carried to 400 deg. C. or above, the decomposition will take place

with almost explosive violence even without further application of heat.

This kind of decomposition is undesirable on account of the excessive production of non-condensable gas, though this gas is largely of the paraffin series of hydrocarbons.

Furthermore, there is not so satisfactory a yield of the gasoline hydrocarbons.

With a slow rate of heating, there is a distinct decomposition at 300 deg. C., and there is possibly some cracking below this temperature.

With a hot flame applied to the container, the residual heat after removing the fire has some effect, but it has been observed that there is additional development of pressure even after the container itself has cooled below the temperature of the oil.

There seems to be little doubt that a temperature of cracking below 400 deg. C. is necessary for a first-class product, and that the lowest temperature possible is to be used.

It would be highly desirable to find a catalytic agent which would sufficiently accelerate the conversion at 300 deg. C. or lower to make such a temperature commercially usable. This would greatly lower the pressure needed, as gasoline at 400 deg. has a vapor pressure of over 50 atmospheres while at 250 deg. its vapor pressure is below 30 atmospheres.

A considerable amount of the pressure developed in a closed system is due to the non-condensable gas as is evidenced by the fact that in a typical conversion 8 atmospheres of pressure remained when the container was cold and when it was originally half filled with mid-continent residuum of 26 deg. Baumé gravity. In the same conversion 40 per cent of 58 deg. Baumé gravity gasoline was produced based upon the treated oil.

In cases where the pressure developed with excessive rapidity there was slightly less gasoline and more permanent gas.

A very good measure of the quality of gasoline produced is the ratio of the specific gravity to the boiling temperature. A very low ratio is an indication of gasoline of high hydrogen content, of good quality and of low refining loss.

Gasoline made by confining the heavy hydrocarbons at a temperature of 380 deg. C. gives gasoline having as good a ratio of gravity to boiling point as natural gasoline. Olefines have a slightly higher ratio than paraffin hydrocarbons, and naphthenes and aromatics have a much higher ratio.

Gas oil cracked in the vapor phase without pressure in muffles at a temperature of 600 deg. C. gives naphtha composed largely of olefines and aromatic compounds and with a large amount of permanent gas of the illuminant type.

Based upon laboratory experiments on cracking petroleum, both in the liquid phase and in the vapor phase, and based upon commercial size tests in the liquid phase at low temperature and the vapor phase at 600 deg. C., the following advantages seem to be shown in the application of the heat to the liquid phase:

- (1) A product of superior quality is obtained.
- (2) A higher yield of refined gasoline is to be had.
- (3) There is a selective action on the oil or heavy portion of the petroleum with freedom from further cracking of the portion in the vapor phase.
- (4) There is automatic removal of the gasoline from the sphere of action as fast as it is formed.
- (5) There is high economy of heat.
- (6) There is deposition of the carbon in the suspended condition in the oil and not on the walls of the heating tubes.

*A paper presented in the Petroleum Session of the Kansas City meeting of the American Chemical Society.

(7) There is high oil capacity with small dimensions of plant.

(8) There is perfect control of temperature.

(9) There is rapid and complete absorption of heat from the furnace.

(10) There is possibility of operating either intermittently or continuously.

The disadvantage in cracking the oil in the liquid phase is the high pressure required for maintenance of equilibrium and the attendant danger of failure of apparatus.

The disadvantages of cracking heavy petroleum in the vapor phase are:

(1) The poor quality of the product.

(2) The over-production of permanent gas due to non-selective action.

(3) The deposition of carbon on the walls of the heating tubes.

(4) The comparatively low yield of refined gasoline.

(5) The high temperature required to get capacity on account of the necessity for quick reaction.

(6) The danger of local over-heating on account of the low specific heat of the vapor.

(7) The large heating area and plant dimensions for any great capacity.

The advantage of cracking by heating the vapor is that in the absence of pressure there is less danger of destruction apparatus with explosive violence.

In consideration of the temperatures at which cracking of oil takes place and in consideration of the vapor pressure developed by gasoline and other light hydrocarbons at the temperature of cracking, it appears that the optimum method of operation for converting heavy oil to gasoline in the vapor phase is to maintain a pressure of 30 atmospheres or 450 lb. per square inch and a temperature of not over 400 deg. C. If it were possible to lower the temperature for rapid conversion by means of a catalytic agent, then, of course, the pressure necessary for operation would be considerably lowered. In practice, heating would be done in a tube furnace with rapid circulation of oil from and to a vapor chamber which also serves as a chamber for the separation of carbon.

Various mechanical arrangements, of course, could be used that would be satisfactory. The tubes should be so designed that they will sustain the pressure at the actual fire-box temperature used regardless of the tem-

perature of the oil. Assuming that a temperature of 800 deg. C. is attained in the fire box, then the tubes should be of 4-in. inside diameter and ½-in. walls. This would give a factor of safety of over 200 per cent, since steel at a temperature of 800 deg. C. has an elastic limit something greater than 5000 lb. per square inch. At 800 deg. C. such a tube would fail at 1250 lb. pressure.

The design of the parts not exposed to the heat of the furnace would be comparatively simple, since they would be subject only to the temperature of the oil or vapor which in no case should exceed 400 deg. C.

In Fig. 1 is shown the relation of the temperature to the development of pressure in cracking mid-continent residuum. Curve No. 1 shows the development of pressure from 26 deg. gravity residuum beginning at 210 deg. C., and the pressure then rising in direct proportion to the temperature up to 290 deg. C., when there is an upward turn of the curve which at a temperature of 320 deg. C. increases without any further increase of temperature. This curve represents the cracking with very slow application of heat and shows the low temperature at which cracking can take place. Curve No. 2 shows the effect of very rapidly heating practically the same mid-continent residuum. In this curve the pressure began to develop at 200 deg. C., and was directly proportional to the temperature up to 345 deg. C., at which temperature the pressure began to develop much more rapidly than the rise in temperature, and when the temperature of 395 deg. C. was reached all application of heat was withdrawn while the pressure continued to develop and with a fall of temperature. Whenever a temperature of 400 deg. C. or slightly above is reached the cracking takes place with almost explosive violence, and with the high temperature the product is not so good in odor and there is more non-condensable gas. The cooling curve comes back to a pressure of about 15 atmospheres, with the pressure in direct proportion to the temperature, but below this the non-condensable gas has its effect, and with a residual pressure of about 8 atmospheres when cold.

Fig. 2 shows the heating curve and cooling curve of mid-continent residuum as to the relation of the temperature in degrees Centigrade and the pressure in atmospheres, and also shows this same relation of the vapor of gasoline and kerosene. It is quite clear that the pressure at which gasoline and kerosene are produced is the point at which the gasoline or kerosene curve intersects the minimum cracking temperature

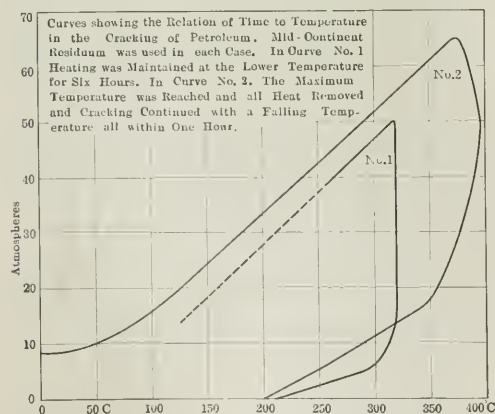


FIG. 1—PRESSURE-TEMPERATURE CURVES OF MID-CONTINENT RESIDUUM

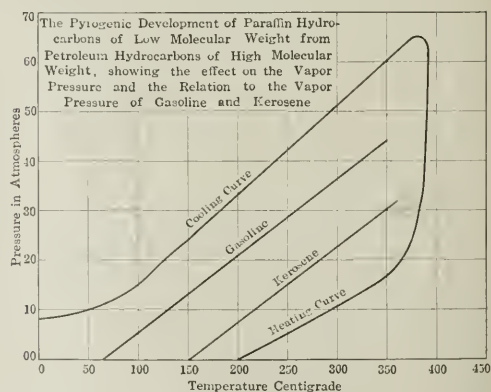


FIG. 2—HEATING AND COOLING CURVES OF MID-CONTINENT RESIDUUM

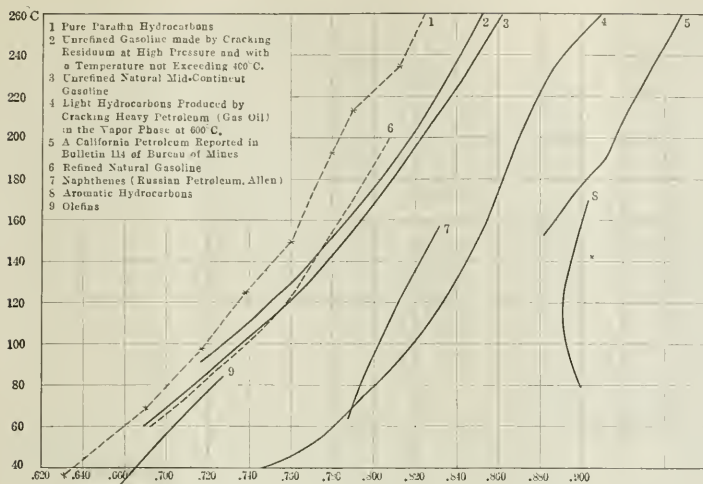


FIG. 3—SPECIFIC-GRAVITY, BOILING-POINT CURVES

line. If the minimum cracking temperature is 300 deg., then there would be gasoline vapor in equilibrium with the liquid phase at a pressure of about 36 atmospheres and with kerosene at about 22 atmospheres. An intermediate point, probably about 30 atmospheres, would be then the best pressure at which to continuously distill gasoline in order to maintain the liquid phase and while heating the liquid phase.

Fig. 3 shows the relation of the specific gravity to the boiling point of various hydrocarbons obtained from petroleum. Curve No. 1 shows the boiling temperatures of the pure paraffin hydrocarbons. Curve No. 2 shows unrefined gasoline made by cracking mid-continent residuum in the liquid phase at high pressure and with a temperature not exceeding 400 deg. C. Curve No. 3 shows unrefined natural mid-continent gasoline. Curve No. 4 shows the light hydrocarbons produced by cracking heavy petroleum gas oil in the vapor phase without pressure and at 600 deg. C. Curve No. 5 shows the California petroleum reported in Bulletin 114 of the Bureau of Mines, which is peculiar on account of the exceedingly high ratio of the specific gravity to the boiling point and very nearly coincides with the curve for aromatic hydrocarbons No. 8. Curve No. 6 shows refined natural gasoline with an end point of 200 deg. C. Curve No. 7 shows naphthenes as given by Allen for Russian petroleum. Curve No. 9 shows olefins. Special attention is called to Curve No. 2, which shows as low a ratio of gravity to boiling point as high grade natural gasoline. This ratio is practically unchanged by refining with sulphuric acid, as the refining loss is almost negligible. Curve No. 4 represents hydrocarbons

composed largely of aromatic compounds, olefins and paraffins being practically 50 per cent aromatic compounds. This in a general way shows the tendency of high temperature and of the vapor phase to produce hydrocarbons having a very high ratio between the specific gravity and boiling temperature.

Fig. 4 shows the effect of high temperature on the elastic limit of steel. From the standpoint of the cracking in the liquid phase the entire success depends upon the margin of safety allowed in the design. At a temperature of about 350 deg. C. there is a very rapid decline in the strength of steel, but this rate is less rapid at an ordinary fire-box temperature, which in cracking in the liquid phase will not exceed 800 deg. C.

This will plainly allow the use of a 4-in. inside diameter cracking tube with a half-inch wall, provided, of course, there are no other elements entering into the deterioration of the steel.

Notes Upon the Hydrometallurgical and Electrolytic Treatment of Zinc Ore*

By E. E. Watts

The war has given a great impetus to the zinc industry, and much attention has been directed to the treatment of complex ores by hydrometallurgical and electrolytic processes.

The possible methods of treating zinc ore for the recovery of zinc may be classified as follows: (1) smelting, (2) chemical, (3) electrolytic, (4) electric smelting.

Smelting includes the standard distillation method for high-grade ore. Distillation may be preceded by igneous concentration.

Chemical methods include various processes for the production of zinc salts or zinc oxide, possibly followed by smelting for the recovery of zinc.

Electrolytic methods include processes for the recovery of zinc by electrolysis, in which electrolysis may be preceded by preparatory chemical or igneous processes.

Electric smelting includes methods for producing zinc, zinc oxide, or zinc dust, by the use of the electric furnace.

EXPERIMENTAL WORK

In 1912 and 1913, at the School of Mining, Kingston, the writer experimented with zinc ore from the Sullivan Mine of Kimberly, B. C. The ore was a dense complex sulphide, of which the chemical analysis was:

Zinc	31.2%	Insoluble	12.8%
Lead	10.1%	Lime	Trace
Iron	13.4%	Sulphur	31.0%
Silver	3.1%		

Microscopic examination showed that the diameters of the mineral particles were as follows:

*A paper read at the Kansas City meeting of the American Chemical Society.

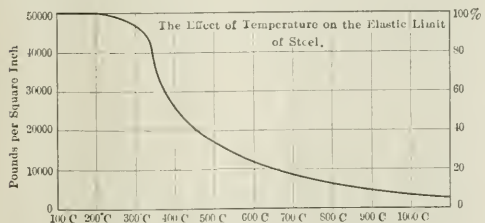


FIG. 4—ELASTIC LIMIT AT HIGH TEMPERATURES

Blende	0.20 mm. to 0.05 mm.
Galena	0.20 mm. to 0.05 mm.
Pyrite	0.10 mm. to 0.025 mm.

The microscopic examination precluded the possibility of a mechanical concentration, and hence left igneous or hydrometallurgical processes as possible means of treatment.

Preliminary roasting and lixiviation tests indicated that a sulphurous acid treatment of the roasted ore would give interesting results. The conditions were worked out for obtaining an 87 per cent zinc extraction by a sulphurous acid leaching, and attention was directed to the recovery of zinc from the resulting solution of zinc bisulphite. The conditions were determined for the precipitation of zinc monosulphite from the zinc bisulphite solution.

The Zinc Commission¹ has pointed out that zinc smelting in Canada, even for high-grade ore, is a very doubtful commercial enterprise. It would, therefore, appear that a sulphite precipitate must be roasted to oxide and exported, or the zinc must be recovered from it in some other way than by distillation.

Tests were conducted to determine if it was possible to obtain metallic zinc by the electrolysis of solutions of zinc bisulphite. The deposition of sulphur and zinc sponge, and the evolution of hydrogen sulphide made this electrolysis impossible. Then attempts were made to obtain metallic zinc by electrolysis of solutions of zinc sulphate to which zinc sulphite precipitate was periodically added. The additions were made to the bath and to muslin bags at the anodes, but the tests showed that in the presence of sulphurous acid or zinc sulphite successful electrolysis was impossible.

Tests were conducted in which the zinc sulphite precipitate was first roasted to oxide before charging at the anodes in a zinc sulphate electrolyte. Successful results were obtained. The zinc deposited in a good plate, and the electrolyte was maintained by the addition of the roasted sulphite. To free the bath from particles of precipitate that might attach themselves to the deposit, to place the roasted precipitate at the point in the bath where the sulphuric acid is regenerated by the electrolysis, and to decrease, if possible, the decomposition voltage by allowing the roasted precipitate to act in part as anode, the crude zinc oxide obtained by roasting the zinc monosulphite precipitate was placed in bags at the anodes of the electrolytic cell.

From the foregoing experiments the following conclusions were deduced:

1. Successful electrolysis is impossible in the presence of sulphurous acid or zinc sulphite.
2. Successful electrolysis is possible with an electrolyte of zinc sulphate to which zinc oxide, prepared in any suitable manner, is charged to compartments surrounding the anodes of the cell.
3. Lead forms a satisfactory anode, and copper, zinc and aluminium form satisfactory cathodes.
4. With current densities of from 2.5 amps. per square decimeter to 4.5 amps. per square decimeter, a current efficiency of approximately 100 per cent can be maintained.
5. Depending upon the current density, the voltage varies from 3.5 to 6 volts.
6. The extraction of zinc from zinc oxide varies from 95 to 100 per cent.

The process, as outlined, was patented, and was developed for the treatment of high-grade zinc ore. The process has been referred to as the Watts Process.

The high-grade zinc product for charging to the electrolytic cells may be roasted zinc concentrate, im-

pure or refined zinc oxide, or zinc dust. The advantages of such a treatment are:

1. The solution is kept small in bulk, and the solution and tanks serve at once for leaching the ore and for electrolysis.
2. The acid generated at the anode is immediately used up at the point at which it is generated, and at the point where it is most concentrated and hence most active. Thorough extraction is thereby obtained.
3. The bath is automatically kept at constant composition and purity, zinc goes into solution with the relative exclusion of impurities.
4. The zinc content of the solution is kept constant, and high-current efficiency is therefore maintained.
5. The conditions are fulfilled for obtaining a good cathode deposit.
6. The residues from electrolysis may be further treated for the recovery of other metals.

LARGER SCALE—EXPERIMENTAL WORK

The writer became connected with the Weedon Mining Co., and in March, 1915, carried on experimental work in the metallurgical laboratory at McGill University. Various ores were treated, including ore from the company's mine at Notre Dame des Angles, Quebec, zinc oxide from Leadville, Colo., and ore from Mineral Point, Wis. The work served to develop a wooden electrolytic tank, asphalt lined, and antimony-lead anodes and aluminium or copper cathodes. The anode compartment consisted of a wood and canvas box which surrounded the lead anode.

In August, 1915, work was started on an experimental plant at Welland, Ont. The equipment consisted of a 100-kw. motor-generator set, a blower for air agitation of the anode solution, a vacuum pump for filtering, 28 electrolytic tanks 3 ft. x 3 ft. x 4 ft. deep, sump tanks, storage tanks, and filter tanks. Standard cast-iron centrifugal pumps were used for handling solutions. An Abbe ball mill was used for grinding.

Roasted Joplin concentrate assaying 60 per cent zinc was the first ore treated at the plant. It was necessary to charge this ore to the electrolytic tanks in the form of a paste, and a small pebble mill was used for mixing the ore into a paste with zinc sulphate solution. From the mill it was fed by hand to the anode compartments at six-hour intervals. With oxide it was possible to use dry charging, and in both cases air pipes in the bottom of the compartments kept the ore particles in suspension.

In the first trial run in the plant an unsuccessful attempt was made to reverse the position of the compartments. Air agitation was used in the bottom of the tanks, and the compartments surrounded the cathodes instead of the anodes. Seven anodes were used per tank. It was found that the solutions would not transmit 800 to 1000 amperes without overheating.

With two anodes per tank, with the compartments surrounding the anodes as in the original experimental tank, and with a current of only 950 amperes per tank corresponding to a current density of 12.5 amperes per square foot, good results were obtained. But, operating in this manner reduced the plant capacity about 70 per cent.

Several expedients were tried for keeping the solutions cool when employing higher currents, but the heat resulting in part from the electrolytic resistance and in part from the chemical reaction at the anode, made higher currents impractical with this form of tank.

Considerable difficulty was also experienced with the compartments, for the canvas used as a diaphragm material developed into a serious weakness, and required constant attention and repairs. Promising preliminary

¹Report of the Commission of the Investigation of the Zinc Resources of British Columbia.

tests were made upon other diaphragm materials, but this investigation was not completed.

Considerable trouble and loss was caused by the tank construction, and great difficulty was experienced in obtaining an absolutely reliable and tight tank. In fact, it was necessary to replace the original tanks, and the new tanks were made with approximately the same cross section but considerably shorter, in order to accommodate two or three anodes. It was possible, therefore, to run two series of tanks in parallel and thereby to double the plant capacity.

The melting of the deposits, which were stripped every two to six days, caused trouble for a time. An attempt was made to strip copper cathodes by dipping them into a bath of molten zinc. Loss by drossing damage to the cathodes and copper entering into the zinc, made this impractical. Melting was thereafter done in a gas-fired crucible tilting furnace. A flux of sal ammoniac was found to be advantageous.

In general, the laboratory experimental results were attained, but our operations did not permit of a sufficient margin for profit. The company did not see its way clear further to perfect the details of the process on a large scale, so the plant was closed in August, 1916.

* When producing zinc at the rate of 8000 lb. per month, or at the rate of 270 lb. per day, the cost of producing zinc was as high as 18 cents per pound plus the cost of the ore.

On the basis of a steady production of 60,000 lb. per month or 2000 lb. per day, the writer estimates that the cost of producing zinc electrolytically should be 4 cents per pound when power is available at \$14 per horsepower year. Costs would be distributed as follows:

	Cents per lb.
Crushing, pumping, filtering and purifying.....	0.6
Electrolysis, including power, labor and repairs.....	2.3
Melting.....	0.8
General.....	0.3
Total operating cost.....	4.0

In a large plant the above costs would be considerably reduced.

Thirty tons of 60 per cent ore were received at the plant, as well as 10 tons of oxide that was manufactured from the ore mined at Notre Dame des Anges, Quebec. About 30,000 lb. of zinc were produced, which averaged 99.95 per cent zinc.

CONCLUSION

The work showed that it was possible to operate upon a commercial scale, but it showed that weakness existed in the diaphragm material, and that many of the mechanical details could be improved. The process possessed advantage over other processes with respect to extraction, current efficiency, and necessary purity of the electrolyte, for good results were obtained in solutions in which ordinary electrolysis is impossible. With a satisfactory diaphragm it seems probable that a higher acid electrolyte could be used with a correspondingly high current density, and it is probable that future development will be along this line.

In conclusion, I wish to acknowledge my indebtedness to Prof. S. F. Kirkpatrick of the School of Mining, Kingston; Dr. Stansfield of McGill University, and Mr. L. D. Adams, president and general manager of the Weedon Mining Company.

Trail, B. C.

Mining Exchange at Fresno.—A Mining Exchange for selling mines and mining stock has been opened in the Trust Company Building at Fresno, Cal. John A. New is secretary-treasurer and J. Duke Murray is manager. The need for this exchange has long been felt in this district.

Note on the Thermocouple Nichrome-Constantan*

By R. W. Woodward and T. R. Harrison

During the course of an investigation at the Bureau of Standards of the temperature distribution in cooling rails of various sections it became necessary to use thermocouples under unfavorable and peculiar conditions. These required that the couples be small and remain constant in their calibration while inclosed to a depth of 4 in. in holes of 6 mm. diameter in steel at 1000 deg. C. in an oxidizing atmosphere without the use of porcelain insulators in the usual manner. Couples of 0.1 mm. platinum, platinum-iridium and of No. 16 B. & S. gage iron and No. 20 B. & S. gage constantan wire were tried and found not to fulfill the requirements of constancy.

After a trial of several base-metal elements a couple of No. 18 nichrome and No. 12 constantan was found to answer the purpose very satisfactorily. These wires had a single asbestos wrapping and were further protected by covering with a thick mixture of kaolin and sodium silicate, winding with asbestos cord and again smearing with a thinner mixture of kaolin and sodium silicate.

A life test of this combination of thermo elements was made, together with others of nichrome-constantan and iron-constantan. These couples were made up in two series, one having only the original asbestos wrapping and the other being protected by kaolin mixture as above. Fig. 1 shows in graphical form the constancy

*To be published as part of a Technologic Paper of the Bureau of Standards.

The Constantan elements were obtained from the Driver-Harris Wire Company and the Electrical Alloy Company.

From Driver-Harris Wire Company.

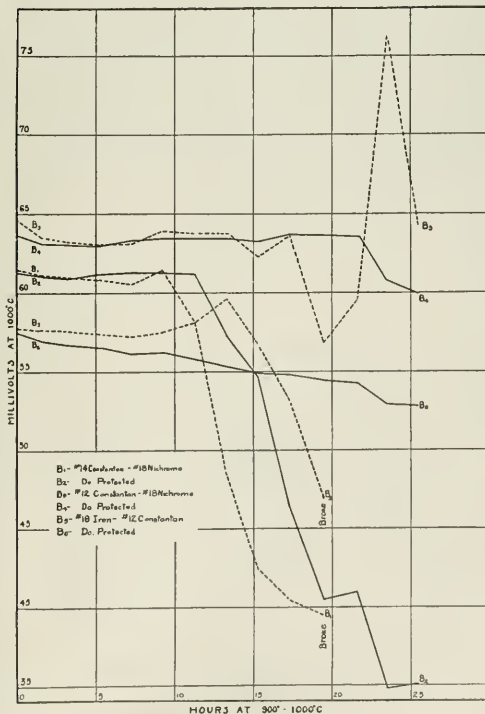


FIG. 1—LIFE TEST OF COUPLES

of these elements when kept for twenty-five hours at 1000 deg. C. in an atmosphere protected only from strong drafts of air. It will be noticed primarily that the protected couples not only have a longer life than those unprotected but that their calibration is more nearly uniform. The couples of nichrome-constantan maintain a very nearly constant calibration—to within 10 deg. C.—during their life, and can be relied upon to 10 deg. C. as long as there is a metallic electrical circuit, whereas the iron-constantan couple has a practically uniformly diminishing emf. The sharp breaks in the curves of Fig. 1 indicate the points at which the couples can be said to be beyond their useful life or to have failed. As would be expected the larger size of constantan wire gives the longer life in the combination nichrome-constantan. In all cases it was the constantan wire that failed, by oxidation and becoming so brittle that it readily broke; the nichrome wire never became brittle and showed no considerable oxidation.

Fig. 2 gives the calibration of the couple nichrome-constantan and the same data are given in Table I. This couple shows a remarkably high emf, the calibration curve is very nearly linear and shows no departure from a smooth curve. This same calibration was found to hold good to within 1 deg. up to 1000 deg. C. for other couples made of wire from the same lot, but it would probably be different for wires from other lots or other wires from this lot.

Couples were constructed of this combination for use in the investigation referred to and to date have been found to give very good service.

For use in air, therefore, to 1000 deg. C., even when only incompletely protected, this data and subsequent experience show that the thermocouple nichrome-con-

Deg. C. Temperature,	Millivolts E. M. F.	Deg. C. Temperature,	E. M. F. Millivolts
168	4.92	632	37.4
204	9.90	842	52.2
292	14.9	1033	66.3
434	23.8		

stantan will maintain its constancy to within 10 deg. C. (18 deg. Fahr.) until nearly completely oxidized. The emf. of this couple is high, 63.8 mv. at 1000 deg. C. as compared with iron-constantan, 57.5 mv. at 1000 deg. C.; nickel-constantan,* 27.2 mv. at 1000 deg. C.; nickel-nichrome,* 28 mv. at 1000 deg. C., and cobalt-constantan,* 39.5 mv. at 1000 deg. C.

*C. Dannecker, Ann. d. Phys., 42, p. 1504; 1913.

*E. F. Northrup, Met. & Chem. Eng., 15, p. 197; 1916.

*O. L. Kowalke, Trans. Am. Electrochem. Soc., 1916, p. 213.

Bureau of Standards,
Washington, D. C.

Some Theoretical Aspects of Electrical Fume Precipitation*

By W. W. Strong

The subject of electrical precipitation illustrates very well the relation between the technical development of a process and the state of our knowledge of the process itself. The practical application of the electrical precipitation of fumes was first made by Lodge and Walker about 1883. At that time absolutely nothing was known of the mechanism of the conduction of electricity in gases. The technical development of the subject was sufficiently far advanced to have made the application of it successful if the proper kind of high-voltage generating apparatus would have then been available. Lodge and Walker, however, had to depend upon an electrostatic machine for their source of corona current and, of course, could never obtain sufficient current to precipitate fumes from any considerable volume of gas.

About 1895 Dr. Cottrell¹ took up the application of electrical precipitation to the removal of certain sulphuric acid mist and smelter fumes from gases. At this time the theoretical development of the conduction of electricity from gases had been very considerably advanced. Dr. Cottrell, however, obtained his success through the fact that the technical development of high voltage generating apparatus had made it possible for him to use enormously larger currents than Lodge and Walker had been able to do. Since Cottrell started the above work, the technical advances in electrical apparatus used for producing high-voltage currents has been very rapid, and it is owing to this condition that the art of electrical precipitation is now becoming so widely applied.

The theoretical advances of our knowledge of the state of a gas or fume inside of the electrical precipitation treater has in the meantime advanced but little, though it is true that the phenomena of ionization in gases has been tremendously advanced in the past fifteen years. These advances, however, pertain more to the conduction of electricity in gases at low temperature, to the ionization produced by radio-active substances and the discharges taking place in arcs and sparks. In the process of electrical precipitation the ionization of the gases invariably takes place at atmospheric pressure and in a region of space in which the electric

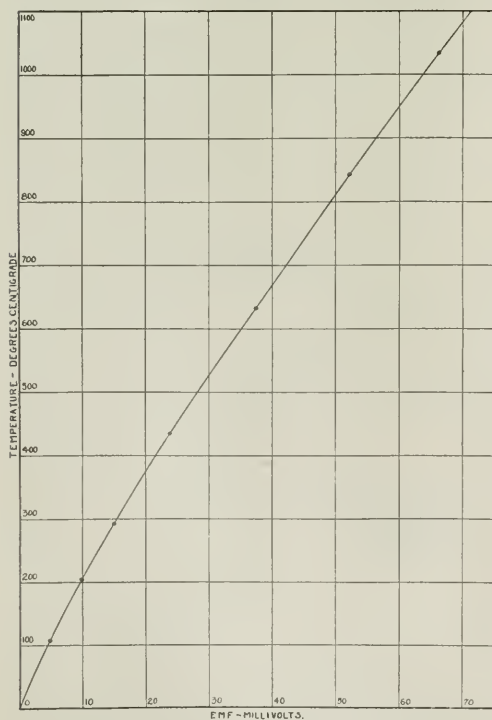


FIG. 2—CALIBRATION CURVE OF NICHROME-CONSTANTAN

*A paper presented in the Symposium on the Smelter Smoke and Fume Problem at the joint meeting of the New York Sections of the American Institute of Mining Engineers and the American Electrochemical Society on January 26, 1917. The other two papers presented in this symposium, by Ligon Johnson and Linn Bradley respectively, were published in our issues of Feb. 15, p. 159, and March 15, p. 345.

¹Cottrell, Problems in Smoke, Fume and Dust Abatement, Smithsonian Report, 1913.

fume, dust or smoke and the amount of electrical charge which it carries.

The nature of the space charges is shown in Fig. 1. In the region of the wire electrode is located the active electrode rays (consisting of positive ion rays if the wire is negative) and a space charged by these rays (region of active electrode space charge); the region of ion formation where ions are formed by the collision of ions with gas molecules and hence a region where the electric field gradient is very great, and which is also the region of the passive electrode rays where the space charge has the same sign as that of the active electrode. These regions of the corona, *a*, *b* and *c*, are characterized by different precipitating properties.

Fume or smoke particles that get into the region *a* are charged and attracted to the active electrode. Fume or smoke particles that get into *b* may be charged with either sign of charge, and may accordingly be driven to either electrode. Fume or smoke particles that get into the region *c* are charged so that they are precipitated upon the passive electrode. In the precipitation of fumes it is always best to prevent the fumes from entering the *a* and *b* regions, where they become precipitated upon the active electrode and cause trouble by interfering with the corona discharge.

The quantity of space charge in a pipe depends upon the nature of the ions and the electric potential impressed on the electrodes. These problems will be more fully considered in a later communication. The effect

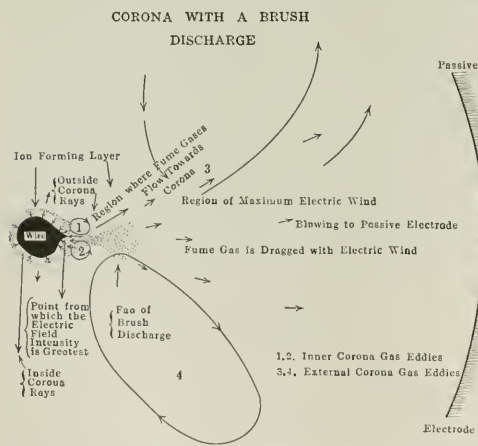


FIG. 2—CORONA WITH A BRUSH DISCHARGE

of space charges is to decrease the quantity of ionization and hence choke down the corona current.

Fig. 2 illustrates how a corona may become unbalanced by the presence of deposits on the electrodes, by a non-uniformity of the fume gases in the treater, and also by the nature of the corona discharge itself. The unbalancing of a corona from its symmetrical discharge about a wire electrode results in the discharge being localized in certain parts of the treater. The pressure of the fume gases is greatest in the localized corona regions, and this sets up eddies in the gases as indicated. Fumes are therefore more likely to pass through that portion of the pipe where the corona is least intense. In a treater consisting of a number of pipes there is always a possibility of the corona becoming localized in a few or even one of the pipes. This localization of

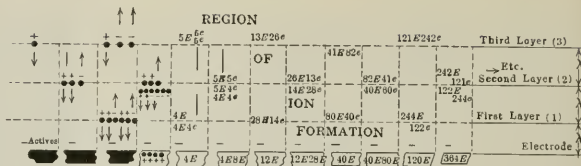


FIG. 3—ACTIVE ELECTRODE SECTIONS

corona may take place without the formation of sparks or arcs.

IONIZATION IN THE CORONA

Fig. 3 shows how a corona current starts and the nature of an ionization current in a gas.

(1) The corona is usually assumed to start from the natural ionization of the gas. The electric field may ionize a gas itself under certain conditions. Fig. 3 shows how ions are easily formed when there is a sufficiently intense electric field acting over a depth of three or more mean free paths. In the figure the mean free path of an ion and a molecule is assumed to be the same, and given the value in air at 76 cm. pressure and 0 deg. C. The length of time between collisions is thus 1/4,600,000,000 second. If this period *T* is magnified to one second, the period of a 60-cycle current would correspond to about three years. It is thus seen that there is equilibrium between ionization and field as regards the starting of the corona, because the question of a few *T* times intervals can be neglected.

The natural ionization of a gas which accounts for the lag effects in point discharges would probably produce a lag effect in the corona discharge. So far no investigations have been made along this line.

(2) The condition of ionization equilibrium is determined by the state existing when the space charge due to the moving ions lowers the electric field so that the rate of formation becomes uniform. This condition should not be confused with the condition of chemical equilibrium, which is very important in the case of the corona discharge in air. Ozone, hydrogen, peroxide, oxides of nitrogen, and possibly other compounds modify the corona discharge, and hence the quantities of these compounds may keep on changing while the quantities of these compounds are changing.

Time	0T	2T	3T	4T	5T	6T	7T	8T	9T	10T
Current flow to active electrode	0	0	0	4E	4E	12E	12E	40E	40E	120E
Through first layer	0	0	0	6	18	18	60	60	180	180
Through second layer	0	3	3	12	12	39	39	120	120	363
Through third layer	1	1	4	4	19	19	58	58	181	181
Space charge—										
Through first layer	1E	0	12	0	5e	0	13e	0	41e	0
Through second layer	0	1E	0	1e	0	1E	0	1E	0	1E
Through third layer	0	0	2E	0	4E	0	14E	0	40E	0

E represents a unit + charge.
e represents a unit - charge.

ITEMS

A space charge that is fluctuating.

A double layer.

The fluctuations of an electrical current in a gas.

An explanation of how a corona starts.

T = 1/4,600,000,000 sec. $\frac{1}{4}$ cycle (i.e. time for e.m.f. to go from 0 to max.) = 1/240 sec.

If *T* = 1 sec. $\frac{1}{4}$ cycle = $\frac{1}{4}$ year.

Fig. 3

(3) Fig. 3 shows how one ion starting at time *T* = 0, produces 2 ions at time *E* = 1, and the action of these ions results in 9 ions being in the gas at a time *T* = 3. In the present case we have neglected ion recombination and diffusion. The figure shows very clearly how at any time the current through various cross-sections of the gas varies, and how the current through the same cross-section varies with the time.

(4) Fig. 3 shows how the moving ions act as a space

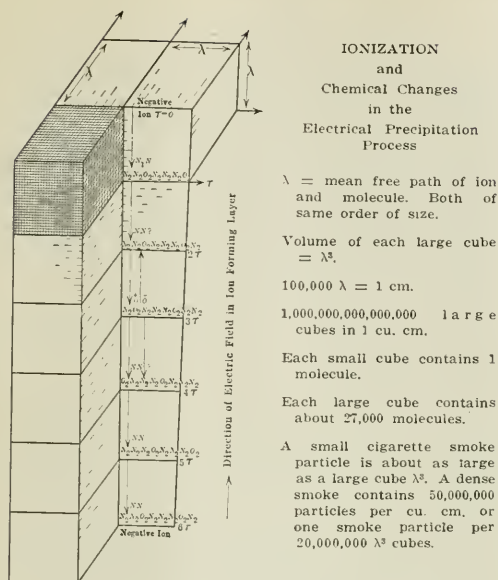


FIG. 4—IONIZATION AND CHEMICAL CHANGES

charge. In the case of the rapidly moving gas ions the space charge does not injure precipitation. It can be shown that the fume ions may be the source of a space charge that will choke back the corona current. The figure shows how the space charge fluctuates at any point.

Fig. 4 is made to illustrate the small part that fumes play in the corona discharge. A mean free path cube (λ cube) is one for which the length is that of the path of an ion between collisions and represents the size of a very small fume particle. Each of these cubes contains 27,000 molecules. In dense smoke there is not more than one smoke particle per 20,000,000 of these cubes. Possibly a better picture of the relative size of these particles is this:

An electron—a pin head.

A molecule—the Engineers' Building in New York City.

A mean free path cube—about thirty Pennsylvania railroad stations packed in a cube.

A small fume or smoke particle—Manhattan Island.

The question is frequently asked as to how theory aids in the application of the electrical method to precipitating fumes, dust, smoke, mists, fogs, etc., from gases, the idea prevailing that the operation is extremely simple. The latter view is entirely incorrect, and the illusion is usually dispelled when a treater is to be kept in continuous operation. In short the accurate knowledge of the phenomena involved in precipitation is useful (a) in improving the apparatus; (b) in making present operation more effective in every way; (c) in accurately comparing the various methods of removing suspended matter from gases, and (d) in opening new fields for technical operation. The possibilities of improvement in the process are very great and the next few years will see even greater advances than in the past. This can be the more readily admitted when it is remembered that the present technical plants have only been out of the laboratory for a few years.

In present operations of electrical precipitation the value of a thorough knowledge of the process is just as

necessary as in the running of an automobile, an aeroplane or any other piece of apparatus. A partial knowledge of a subject may be sufficient for most cases, but circumstances invariably arise that require technical and perhaps even theoretical skill. It is too easily forgotten, too, that the theoretical knowledge of to-day becomes the technical skill of to-morrow. A résumé of these problems will be made in a later communication. A full knowledge of the precipitation of suspended matter from gases is necessary for the proper comparison of the centrifuge, the settling, the washing, the electrical and other processes used for cleaning gases. The fixation of nitrogen, the formation of ozone, the disinfection of gases, the differential separation of different materials from gases and the conservation of the heat in gases, are among the many wider applications of the electrical process.

The theory of the corona discharge (with further experiments to make it apply to each type of smoke, dust, fume, mist or fog that constitutes a commercial problem) permits determination of—

(1) The exact calculation of the paths of the fume ions in a treater.

(2) The life of the fume ions and the time required to precipitate them.

(3) The evaluation of the precipitation constant.

(4) The effect of space charges.

(5) The amount of energy flowing into the treater that is actually expended in the precipitation of the fumes.

(6) The maximum velocity of the fumes for complete precipitation.

(7) The calculation of the best size and type of electrodes for a given type of fume.

(8) The best process to apply when it is found difficult to ionize fume particles.

(9) The smallest sized treater necessary to clean a given volume of fume in a given time.

(10) The separation of particles of a substance when a part of a mixture.

(11) The separation from each other of substances that possess different volatilities.

(12) The effecting of chemical reactions such as the fixation of nitrogen, the oxidation of various substances, etc.

(13) Probably the most important application is that of giving a perfect knowledge of the subject in place of a hit-and-miss, vague guessing and surmising state of knowledge that leads laymen to suspect the engineers connected with the work. This psychological effect has played a very important rôle in the past and will be important in the future.

Some of these items have been treated in previous papers, some in the present one, and a complete treatment of the whole subject is being prepared.

THE LIFE AND TRACKS OF FUME IONS

The fumes enter the precipitator pipe at a density of n particles per cu. cm. These particles become ionized to fume ions and are driven to the pipe by the electric field. The time thus required to precipitate a fume ion will be defined as the life of a fume ion and the path it traverses as the track of the fume ion. The longitudinal velocity of the fumes through the pipe does not affect the life of the fume ion excepting as they may cause a modification in its charge, but it changes the tracks of the fume ions very greatly.

Consider a pipe treater with a corona of radius r_c , pipe of radius R and a cylindrical shell of radius r and thickness dr within the treater. The fume particles become fume ions gradually, but for complete precipitation all the particles become ions. The fume particles

$2\pi nrdr$ in a unit length of shell eventually become fume ions, each traversing a distance $R - r$ to reach the pipe.

The total distance traversed by all the fume ions of this unit section before precipitation is,

$$\int_{r=R}^{r=r_c} 2\pi nrdr(R - r_c) \quad (1)$$

The number of fume particles is

$$\pi n(R^2 - r_c^2) \quad (2)$$

(1) divided by (2) gives the average length of track of the fume ion as projected on the r axis,

$$\frac{1/3R^2 - Rr_c^2 + 2/3r_c^2}{R^2 - r_c^2} \quad (3)$$

In precipitation work $R = 30r_c$ approximately, (3) becomes 0.3330R.

The velocity v of a fume ion is the product of the electric field intensity by the mobility K ,

$$v_r = E_{vK} = k \frac{Ep}{r \log_2 \frac{R}{r_c}} \quad (4)$$

The fume ions will be carried longitudinally along the pipe by the fume gases with a velocity v_e in the y direction. One has the velocities

$$\frac{dr}{dt} = v_r, \quad \frac{dy}{dt} = v_e \quad (5)$$

$$\int r dr = \int \frac{Ep k}{\log_2 \frac{R}{r_c}} dt, \quad \int dy = \int v_e dt \quad (6)$$

In the simplest conditions where the constants of integration disappear,

$$1/2r^2 - 1/2r_c^2 = \frac{Ep k}{v_e \log_2 \frac{R}{r_c}} y. \quad (7)$$

This is the general equation giving the track of the fume ion in a gas.

Let V be the potential difference applied across the electrodes, E_r the potential gradient at any point r cm. from the center, E_c the voltage drop between the corona and wire and E_p the remainder of the voltage drop, the driving potential precipitating fume ions to the pipe.

$$E_p + E_c = V \quad (8)$$

The potential gradient at any point neglecting space charges would be (where a is the radius of the wire),

$$E_r = \frac{V}{r \log_2 \frac{R}{a}} \quad (9)$$

The effect of space charges upon the value of the potential gradient will be treated in a later paper. It seems quite certain that any choking of the corona current by space charges is due to ions possessing a mobility of less than 0.1 cm. per second.

$$P = \frac{Ep k}{v_e \log_2 \frac{R}{r_c}} \quad (10)$$

is the precipitation constant, the most important factor to be considered in the precipitation process. The following table gives the value of P for various sized pipes for $K = 0.001$ and $V = 5$ ft. (150 cm.) per second.

THE PRECIPITATION CONSTANT			
	6 In. (15 Cm.)	9 In. (23 Cm.)	15 In. (38 Cm.)
	Pipe	Pipe	Pipe
25 deg. C.....	0.57	0.55	1.42
400 deg. C.....	0.25	0.37	0.63

The application of the above equations will be taken up in detail in a paper to follow the present one.

CONCLUSIONS

1. The term "corona discharge" has been defined as the luminous and ionizing electrical discharge taking place from the wire electrodes of an electrical precipitation treater. The term "point discharge" need not be used in precipitation work. The term "brush discharge" may be applied to the fan-like parts of the corona discharge as it appears under certain conditions.

2. The two different "regions" of the corona discharge as regards precipitating action and space charges has been described. It has been shown how important it is to keep the fumes to be precipitated within the "region of passive electrodes precipitation."

3. The space-charge effects of the small ions of the corona are described. The fact that these space charges do not interfere with electrical precipitation shows that any choking of corona currents by space charges must be due to the large ions.

4. It has been shown how whirls and eddies can exist in the corona discharge and how it may be possible for eddies to exist that possess different senses of rotation. It may be that through the action of eddies of this kind fume particles may be carried within the ion-forming layer.

5. The description of the ionization process in precipitation treaters indicates how easily the deposit of a layer of insulating material about the active electrode may result in the piling up of space charges in this region and then sparking.

6. The greater the space charge in a treater the less the voltage that can be impressed upon the treater. This follows from the fact that the field of the space charge is in the same direction as that of the treater electrodes, and passes generally through the ionizing layer. Theoretically, the ideal condition would be $R/r_c = e$. Practically this usually exceeds 30, due to the action of space charges.

7. On account of lack of time, the life and tracks of fume ions, the theory of the corona and the application of the precipitation constant have only been touched. Subsequent papers will treat these subjects fully. A proper treatment of this kind makes precipitation engineering an exact science and puts the whole subject on a mathematical basis. The life of a fume ion is usually less than the quarter period of a cycle.

8. An indication is given as to how the charging of fumes can be made more efficient.

9. The great advances in fume precipitation in the future will be made as regards

- (a) The more efficient charging of the particles.
- (b) The maintenance of the corona more continuously and uniformly at its maximum value.
- (c) The useful applications of the chemical power of the corona as well as its precipitating power.

The present paper is one of a series in which the preceding numbers are as follows: I. The scientific classification of smoke, Rauch and Staub, December, 1911; II. The precipitation of smoke, dust and fumes by electricity, Raub and Staub, June, 1912; the electrical precipitation of suspended matter in gases, *Journal Franklin Institute*, September, 1912; III. The positive and negative corona, A. I. E. E., June, 1913; IV. Theory of the removal of suspended matter from gases, *Journ. Ind. and Eng. Chemistry*, October, 1913; V. Electrical precipitation, *Journal of Engineers' Society*, Harrisburg, 1914, etc.; VI. Smoke monitor, *London Electrician*, June 5, 1914, etc.; VII. Theory of the removal of suspended matter from fluids, A. I. E. E., February, 1915; VIII. Elektrische Fällung, *Ann. d. Phys.*, October, 1915.

Potash from Cement Mills

Cement dust contains potash. Recovery of cement dust by the Cottrell process is not only a protective measure, preventing suits for damage caused by the cement dust, but can be actually made a source of income because of its potash content.

This very ingenious suggestion was first made by Dr. Cottrell in a lecture before the American Institute of Mining Engineers in 1912 (this journal, Vol X, p. 173), and this particular problem of electrostatic dust precipitation was taken up by the Western Precipitation Co. As mentioned in our Vol. XV, p. 512, its pioneer plant in this field is the Riverside Portland Cement Co., at Riverside, Cal., while the Security Cement & Lime Company at Hagerstown, Md., was the next to take it up.

A recent interesting statement of the Bureau of Mines deals at some length with the Riverside plant, and says that it is now making potash with cement as a by-product.

"This is certainly an interesting development of modern industry, where an apparatus installed for the purpose of saving the life of the factory, turns out to be the center of operations around which the entire plant is adjusted, the incidental profits being sufficient, at least during the continuance of the war, to make the former operation of the factory as secondary in importance.

"As there is not sufficient market to take all of the cement, the surplus clinker will be stored until the end of the war. Assuming an 0.8 or 1 per cent potash contained in the raw mixture, it is expected to pay the entire operating cost and a reasonable profit from the sale of the potash alone, giving the clinker as absolute profit. It is expected to manufacture 5000 barrels of cement per day.

"The potash extraction plant has apparently proven its value, and on the average 90 per cent of the total potash contained in the Cottrell treater dust is being recovered in the form of crystallized salts. These crystallized salts, according to the information received, average 80 per cent potassium sulphate and 20 per cent sodium sulphate.

"At the present time the factory is still selling some high-grade potash dust, but most of the precipitated material is being leached for the purpose of converting the potash into high-grade salt. The company can make a greater profit from this procedure, as it is reported that they have closed contract for the sale of these salts at \$6 per unit of K_2O as against \$3 per unit of K_2O in the treater dust when the latter is used directly as a fertilizer. It is planned to discontinue the direct sale of the treater dust as soon as the leaching plant is properly reconstructed.

"The operation of the leaching plant is first to agitate the dust with hot water near the boiling point, then to filter the sludge in an Oliver filter, the filter cake being washed with hot water. This wash water is either returned to the leaching agitator, or, if the volume is small and potash concentration high, is added to the main potash solution and sent to settling vats. In the leaching agitation it is aimed to obtain a 4.5 per cent solution of K_2O , this having been found to be the most economical concentration. Approximately 25,000 pounds of dust are treated at a batch, the leaching operation requiring approximately forty-five minutes.

"The filter cake is at present being sold for soil dressing. The material is stacked and dried, during which procedure the calcium hydroxide largely carbonates. This finely divided calcium carbonate containing a small amount of potash makes a good soil correctant. It is intended eventually to return this filter cake to the kilns

to be burned to cement, but at present this is a difficult procedure, as the undried material is a very sticky, plastic mass.

"The potash solution from the filter, containing some lime, is sent to low, shallow, concrete vats. Here the last portion of calcium sulfate separates out and the potash-soda solution is pumped to crystallizing vats which are merely open kettles, heated from below by direct firing. The solution is added to these kettles, and the boiling is continuous. The crystallized salts are hoed out from the bottom of the vats, dried, ground, screened and sacked for shipment. The present leaching equipment is crude and necessarily the operating expenses are comparatively high.

"A patent has been allowed covering this leaching operation. The patent covers the specific mode of operation which is utilized and the control of temperatures and solution concentrations, by means of which an 80 per cent potassium sulfate is obtained as a final product. It seems to be impractical or even impossible to obtain a purer material due to the precipitation of double salts of potash and soda—all in accordance with the disclosures of Van't Hoff in the report on his investigations on the various forms of crystallization entering into the Stassfurt deposits of Germany. In this report mention is made of the different complex salts crystallizing from a soda-potash solution.

"It is the intention of the plant management to operate in accordance with the Huber and Reith calcium fluoride patent, and tests were conducted upon this during the past few weeks. According to the information received these results were very gratifying. The feldspar used in these tests averaged about 10 per cent K_2O and the amount used was approximately one part of feldspar to six parts of diorite. This was an orthoclase feldspar obtained near Perris, Cal.

"The tests were conducted upon an 0.8 per cent K_2O raw mix. The reason for limiting the potash content to this figure was the desire to move cautiously in the modification of the raw mix, due to the necessity of maintaining a proper cement product. Also the supplies of feldspar and fluorspar were somewhat limited.

"The chemical reactions involved in the utilization of fluorspar are set forth in the Huber and Reith patent. The fluorine reacts to give volatile potassium fluoride, which is collected with the dust and upon leaching the dust this fluorine reacts with the lime to form insoluble calcium fluoride, which again becomes available for reaction in the kiln on the return of the filter cake to the raw feed.

"The elimination of potash was apparently very satisfactory. The potash content in the clinker was brought down to 0.12 per cent K_2O and with proper control of kiln firing and feed adjustments it is hoped to do still better. The supply of material on hand was not sufficient for more than a short run of two or three days.

"Assuming an 0.8 per cent content in the raw mix, this represents a little better than 90 per cent volatilization. Then taking a 90 per cent extraction in the leaching plant as above outlined, this would give probably 75 per cent recovery of the total potash in the raw mix as a final product of crystallized potassium sulphate when assuming a reasonable treater efficiency."

Willard Gibbs Medal.—The seventh annual Willard Gibbs Medal was presented to Dr. Edward W. Morley at a meeting which was held at the Hotel Sherman, Chicago, May 18. Dr. Morley talked on his early work in connection with hydrogen and oxygen. Other recipients of the medal have been: W. R. Whitney, A. A. Noyes, T. W. Richards, Ira Remsen, L. H. Baekeland and Svante Arrhenius.

Grading of Graphite, Gunpowder and Malt

By Edward S. Wiard

Graphite

The mining of graphite is a very hazardous business undertaking and one accompanied with slight success even where conditions are most favorable. Graphite is of four kinds, the amorphous graphite of Mexico, artificial graphite, flake graphite, and fibrous graphite, the bulk of which comes from Ceylon. Graphite as mined in the United States was confined until recently to the Adirondacks region of New York State. Here the deposits are in schists through which the graphite is disseminated and the separation from the accompanying minerals, particularly mica, is very difficult. The Joseph Dixon Crucible Company, owing to its manufacture of the dressed graphite into various products, is, practically speaking, the only company mining in the region which has had stability. Some of the causes contributing to the decline of the graphite industry in the United States are: the superiority of other forms of graphite and the greater cheapness with which these are mined, and, in the case of the Ceylon graphite, its delivery to the market in a refined condition. Recently, however, there has been marked activity in graphite mining in Texas.

The use of flake graphite is practically confined to the manufacture of lubricants and foundry facings. Ceylon graphite is exclusively used for making crucibles and to a minor degree in the manufacture of lead pencils. Much of it also goes into foundry facings and stove polish. Ceylon graphite can be laid down in the lump or best grade at Eastern factories for about 9½ cents per lb. in barrels holding about 600 lb. There is about 92 per cent pure carbon in this grade. The best grade of finished American flake does not bring over 7½ cents a lb. In 1913 the imports of Ceylon graphite to the United States amounted to 8374 tons, valued at \$920,147. The domestic production amounted to 4336 tons, worth \$324,118 in the same year. The United States takes about a third of the Ceylon output.

In the Ceylon deposits the graphite occurs as veins in gneissic rocks and in crystalline limestones which are interbedded with these rocks. The veins consist of pure fibrous graphite and are from a few inches to several feet wide. Following mining in open pits or very shallow underground openings, the mineral is screened, then cleaned by cobbing and sorting. Following these operations various kinds are blended to suit the requirements of purchasers. The poorer material remaining from the sorting and cobbing operations is ground to a powder by hand beaters and then graded.

In the Adirondacks there is no well defined system of milling; the flowsheets of the mills vary widely and often employ separating machines which are only partially successful or which are in the experimental stage. In some mills the procedure may be generalized as follows: The ore is crushed to about 5 mesh and then submitted to a flotation process to remove the fines. What does not float is then dried, graded and air jigged. The cleaned product resulting from the jigging is ground in buhr mills and bolted in gyratory bolters.

The points which make graphite valuable as a crucible material are that it does not fuse below temperatures at which most metals and alloys melt. Less fuel is required to make a melt owing to the good conductivity of the graphite. Graphite crucibles stand sudden changes in temperature well. A flaky product is required and the least of this used the greater the amount of refractory material which must be added to hold the mass together, thus enhancing the value of the crucible.

The graphite is ground in buhr mills, the number of

grooves cut in the stones being fewer than when such stones are used for other purposes, the idea being to flatten the fibrous graphite rather than to grind it. From the mills the graphite is elevated to gyratory bolters, the coarsest screen used not exceeding a 12 mesh. The oversize from this screen is returned to the grinding mills. The next size screen may be a 16 mesh and the third a XX silk cloth. The first two screens are brass cloth. The undersize of the XX is used as foundry facing and stove polish. The gradings from the bolter are mixed with the proper proportion of sand, kaolin and water and carefully weighed balls of the mixture are introduced into revolving plaster molds.

While the mold is revolving with its contents a curved blade of the contour of the interior of the crucible is lowered a number of times to force the mass up against the mold, coating the interior of the crucible to the desired thickness and producing a skin which completely lines the crucible. The lip of the crucible is put on by a few deft movements of an attendant, a portion of the mold being removed for this purpose. The mold and contents are allowed to dry for about seven hours when the green crucible is removed to a rack to finish the drying. In the kilns the crucible is at a red heat for one week.

Foundry facings and material for stove polish are also made by grinding inferior grades of Ceylon graphite in buhr mills, followed by screening. Ordinary and centrifugal silk reels are employed for grading the ground graphite. As many as seven sizes of cloths are attached to the reels. Flake graphite for lubricants is prepared at the mine mill, the compounding of the lubricant being done at the factory.

In the manufacture of lead pencils the principal ingredient is amorphous graphite which comes mainly from the Santa Maria graphite mines of Sonora, Mexico, situated about 20 miles south and a little east of La Colorado in central Sonora. These are the largest amorphous graphite mines in the world and the quality of the product is typical. The graphite occurs in sandstone which has been intruded by granite; the graphite being the result of the metamorphism of coal beds by the igneous rocks. In other parts of the same region all grades of coal are found from soft to anthracite.

The product mined is sufficiently pure to ship directly to the plant of the United States Graphite Company, who own the mines, and where the refining process consists in grinding in tube mills. From these machines the product passes into Raymond air separators. The tube mills are run in closed circuit, the coarse material dropping back into the tube mills. The finished product is impalpably fine. Large amounts of the Mexican graphite are exported for pencil making, it being equal to the Bohemian and Bavarian graphite for this purpose.

The best pencils are a careful blend of amorphous graphite and Ceylon graphite. The Ceylon graphite adds to the smoothness of the lead, the amorphous adds unctuousness and flowing quality, which can be obtained with no other form of graphite. In making pencils the graphite is mixed with carefully refined clay. The greater the proportion of graphite the softer the pencil and the more the proportion of clay the harder the resulting pencil lead. Following the thorough mixing the ingredients are forced into molds and when the green leads are sufficiently dried they are baked.

In the manufacture of artificial graphite, anthracite coal or oil coke is charged into electrical furnaces and subjected to the highest possible temperature. The material fed to the furnace is crushed to at least one-half inch by corrugated rolls. After the mass has been removed from the furnaces and cooled it is broken up and passed into tube mills and from these machines it goes to air separators, the regulation of the blast giving

as fine or as coarse a product as is desired within certain limits. The capacity of the separators varies from 600 to 1000 lb. per hour. The grades made are determined by the proportion which will pass a 200 mesh screen, the range being from 75 to 99 per cent. There is also a grading according to the purity of the graphite. The finest and best grade of the artificial graphite is used for clamp paste for incandescent lamps. Other grades are used for lubricants, paint, electrodes and electrolyzers use. The suspended forms in oil and water for use as lubricants are of great interest and value. Artificial graphite is not used for pencil making as it is lacking in an unctuous quality.

Gunpowder

Most black powders, outside of cannon powder, are graded so as to regulate the burning effect. The finer the powder the faster the burning. As the powder becomes successively comminuted, however, the increase in the length of the interstitial passages lowers the rate of burning, since, owing to increased friction, the heated gases cannot pass so rapidly to the interior of the charge. The laws of some states require that black blasting powder shall be rigidly graded into a prescribed number of sizes.

The principal use of black powder is for blasting in coal mining. Thus in Illinois the black blasting powder must have a range of specific gravity between 1.74 and 1.90 and when leaving the factory have a moisture content not to exceed 1 per cent. Seven sizes are prescribed, CCC a powder which will pass a screen having round holes, 40/64-in. in diameter, and remain on a screen with holes 32/64-in. in diameter. CC powder, which will pass a screen having round hole perforations 30/64-in. in diameter and remain on a screen having perforations 24/64-in. in diameter, etc. The smallest size FFFF, is one which will pass a screen with 5/64-in. openings and refuse a screen with 2/64-in. openings.

In the manufacture of a nitrate or chlorate powder the oxidizing agent is mixed with sulphur and carbon in a form of Chilean mill, a little water being mixed with the charge is ground for four or five hours. Great care has to be exercised that the powder does not flash by the rollers coming in contact with the pan. After the powder is thoroughly incorporated it is passed through rollers and is then made into sheets by a hydraulic press. Following this operation it is granulated by passing through toothed rollers with varying sets. It is then screened on flat brass screens, then dusted in revolving screens and glazed with graphite, about $\frac{1}{2}$ oz. being used to the 100 lb. of powder. After thorough drying the grains are again dusted.

The evenness of burning of powder depends upon thorough incorporation of the ingredients, invariably of composition, careful and close grading and uniformity of the shape of the grains.

Malt

Malt is converted barley. The barley is cleaned by methods which are similar to those described under wheat. In malting the barley is first steeped in water from 24 to 40 hours, which causes the grain to take up from 10 to 30 per cent water when it swells and begins to germinate. Following this operation the grain is piled up and the heat created by vital actions conserved, the growth thus being stimulated. The grain is then stirred to check the growth of the rootlets and to stimulate the growth of the acrospires. Finally the grain is dried, the germination being completely checked. A malt kiln is used for this purpose. The grain is then screened when the rootlets and acrospires fall off.

The chemical changes effected are the conversion of azotized substance into diastase, the conversion of starch into grape sugar and the imparting of color and flavor to the malt. The malt is either light colored or dark according to the amount of heat used in the kiln. When heating is prolonged more empyreumatic oil accumulates in the grain and it has a sharper, stronger flavor.

The principal advantage which would result from grading barley would be that with uniform-size berries, the germination period would be about the same for all the individuals and the various steps in the malting process would be better defined and easier regulated.

The Rich grader has been proposed for this service. (U. S. Patent 410377, Sept. 3, 1889 and later ones.) It consists of batteries of disc rings held together by rods and nuts and spaced by washers. The rings are kept free by a brush device. It is said that all grain is of about the same length and varies in dimension only in thickness. The Rich grader allows the grains to pass through the openings in a direction parallel to the short axis, a condition impossible to obtain with any other screening device. Even if the grains were of the same thickness in all directions the close sizing required could not be effected by screens.

The McKesson machine principle could also be employed for the same purpose, or for grading coffee and beans, uses for which the Rich grader has been proposed.

Specific Gravity in Rubber Compounding

By Andrew H. King

The first thing the young compounder learns is an appreciation of specific gravity. As is well known, this term is simply the ratio of the weight of a given volume of the substance to that of an equal volume of water. In the metric system the word "density" is substituted, and the term becomes mass per unit volume; in other words, grams per cubic centimeter. Density is so intimately bound up with cost that the term volume cost, *i.e.*, price per pound times the specific gravity, is generally used as a basis of comparison for the various stocks. The justice of this scheme becomes apparent when one considers the importance of volume. Only in a few lines is the manufactured article sold by weight. The consumer is not long in discovering the shortage when packing of 2.10 sp. gr. is substituted for that of 1.40 sp. gr. The question then is, with most stocks, how far will 100 lb. of it go? This known, the price per pound is then to be considered. For the sake of clearness, let me say that the above applies to the great number of stocks in daily use in the rubber factories, and not to that small portion which yield a porous product, as for example, sponge stocks. In this case it is *apparent* specific gravity which counts.

The specific gravity of a stock may be determined by a number of methods. These may be outlined as follows:

1. *Balance*.—This method depends upon the law of Archimedes, which states that a body immersed in a liquid loses a weight equal to the weight of the displaced liquid. The piece of rubber is suspended on the left arm of a balance by a silk thread and weighed. It is then immersed in water and thoroughly wetted; all air bubbles are carefully removed. This may be facilitated by first immersing the sample in alcohol. Subtracting the weight in water from the weight in air gives the loss of weight in water, which represents the volume. Consequently the specific gravity is obtained by dividing the weight in air by the loss of weight in water. Some operators make allowance for the weight of the thread or string, but for ordinary work this is unnecessary.

2. *Jolly Balance*.—Here instead of the weights of the

chemical balance we have a coiled spring. One pan is so arranged as to be always in air, and the other one always in water. Observations are made by reading the position of the image of some object attached to the base of the spring in the mirrored scale placed behind. It is well to read the zero position both at the beginning and at the end of the operation. The sample is first placed in the upper pan and the reading taken. It is next wetted and placed in the lower pan. The zero reading is subtracted from these two, which now becomes analogous to the weight in air and the weight in water. The calculation is the same as above.

3. *Young's Gravimeter*.—This instrument (Figs. 1 and 2) has been placed on the market within the past year or so, and when in the hands of a skillful operator gives satisfactory service. The operation is simple. The sample is suspended on the hook, and the nut turned until the arm is balanced. In this position it is parallel with the plane of the table (Fig. 1). After wetting the sample first with alcohol it is immersed in water and the containing vessel raised up until the arm comes to rest (Fig. 2). The specific gravity is read off direct from the scale. From 1.00 to 2.5 the scale is fairly accurate, but beyond this the divisions are too close together. It is true, however, that fully 75 per cent of the stocks in daily use do not have a specific gravity in excess of 2.5. The idea is good, and it is hoped that it will be refined and made more sensitive. It is not suitable for determining the gravity of fillers.

4. *Picnometer*.—The ordinary specific gravity bottle used in determining the density of liquids is of great value when porous stocks must be examined. The sample is best cut into small pieces, placed in the bottle, and weighed. Fill the bottle about half with distilled water and gently boil for a few minutes in an oven. Let cool and attach to an ordinary water suction pump. Let run for an hour or more. In this way all the contained air will be removed. Calculations are as follows:

Weight of bottle when full of water	= a grams
Weight of bottle	= b
Weight of water contained	= a - b
Weight of bottle + sample	= c
Weight of bottle	= b
Weight of sample	= c - b
Weight of bottle + sample + water	= d
Weight of bottle	= b
Weight of sample + water	= d - b
Weight of sample	= c - b
Weight of water contained in presence of sample	= d - c
Weight of water when full	= a - b
Weight of water displaced by sample	= (a - b) - (d - c)
Volume of sample	= a - b - d + c
The specific gravity or density (grams per c.c.) is then	$\frac{c - b}{a - b - d + c}$

The method is equally satisfactory for pigments.

The theoretical gravity of a stock can be easily calculated from the gravities of the various compounding ingredients. The values given below are not to be taken as absolute, since all fillers are more or less impure and will therefore vary in gravity. These figures have been found to be satisfactory in the great majority of cases.

Most compounders make their batches add up to 100

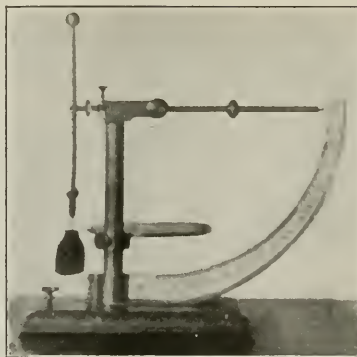


FIG. 1—FIRST POSITION OF GRAVIMETER



FIG. 2—SECOND POSITION OF GRAVIMETER

Filler	Sp. Gr.
Antimony sulfide	3.20
Arsenic, yellow	2.75
Asbestine	2.60
Aluminium bronze	3.20
Aluminium flake	2.65
Barytes	4.35
Blue, ultramarine	2.40
Black, bone	2.20
Black, lamp (gas)	1.72
China clay	2.40
Calcium sulfate, gypsum	3.20
Glass, powdered	2.49
Graphite	2.18
Hydrolene	1.00
Litharge	9.25
Lead, white	6.10
Lead, sublimed white	6.20
Lead, red	8.35
Lead, chromate	5.80
Lime	2.75
Lithophone	3.95
Magnesia, Oxide, Usta	3.45
Magnesium carbonate	3.00
Paraffine	0.95
Plumbago	1.95
Pumice	2.23
Red oxide, iron oxide	4.70
Rosin	1.05
Rubber (all varieties)	0.95
Sulfur	2.07
Substitutes (all varieties)	1.00
Tar	1.10
Talc	2.70
Tripoli	1.95
Vaseline	0.90
Vermillion	8.10
Whiting	2.68
Zinc oxide	5.60
Zinc chromate (yellow)	3.49

lb. This is a great help in figuring costs and in preliminary calculations. The following is an example of the method of calculating a theoretical gravity:

Ingredients	Per Cent Composition Grams to 100 of Stock	Density in Grams per c.c.	Each ingredient per c.c.
Rubber	45	0.95	47.37
Sulfur	3	2.07	1.45
Lime	2	2.75	0.73
Zinc oxide	25	5.60	1.46
Red oxide	10	4.70	2.13
Barytes	5	4.35	1.15
Tripoli	10	1.95	5.13
	100		62.42

Therefore 100 grams of the stock is contained in 100
62.42 c.c., or the specific gravity is $\frac{100}{62.42} = 1.60$.

It frequently happens that a compounder is required to furnish a stock of certain gravity besides conforming to other specifications. In such a case he will decide how much rubber is necessary, then from the period of vulcanization desired he can aim at how much sulfur and how much accelerator is necessary. He will next prepare a chart as above, and juggle his fillers until the right volume per 100 grams stock is obtained.

Synopsis of Recent Metallurgical and Chemical Literature

Benzene and Toluene from Cracking Petroleum Oils.

—In the *Oil, Paint and Drug Reporter* of May 7, 1917, ANDREW BENDER claims that the Rittman process has turned out a failure in commercial practice. Concerning the Aetna Explosives Company's Rittman installation which was abandoned a year ago, he says that during the last six months the plant was operating an average of 8,500 gallons per day of oil were put through the furnaces. Analysis of the cracked oil showed an average 3 per cent of benzene and $2\frac{1}{2}$ per cent of toluene on the basis of the oil used. Only about half of this small amount of benzene and toluene could be removed from the oil on subsequent refining, and neither of these hydrocarbons could at any time be obtained sufficiently pure to be profitably used. The heavy oil containing much carbon as it came from the furnaces was, after settling, distilled in fire-heated stills, and the distillation was stopped when the vapor reached 177 deg. C. The residue was put through the furnaces again. The distillate, called "Rittman distillate," was next "refined." This distillate contained a relatively large amount of sulphur dioxide. Corrosion of the refining stills made it necessary to next distill this oil in simple non-fractionating stills, passing the vapors through caustic liquors to remove the sulphur dioxide. The distillate, freed from SO_2 , was next distilled in fractionating stills. Fractions which correspond in light oil refining to "Heads," "Crude Benzol," "Intermediates," "Crude Toluol" and "Residue," were made. The crude benzol and crude toluol fractions were washed with 66-deg. sulphuric acid in the usual way, to remove unsaturated hydrocarbons, which were present in unusually large amounts. The use of the necessary large amount of sulphuric acid caused excessive heating, which made this step of the process difficult and expensive. After washing with caustic soda, and finally with water, the benzol and toluol fractions were next rectified by further distillation. Unfortunately, these oils contained many paraffin hydrocarbons of approximately the same boiling points as benzene and toluene, and after repeated redistillations at one-half to one-fourth the usual rate of distillation, benzene and toluene of only 89 to 93 per cent purity could be obtained.

The best benzol obtained, and averaging 91 per cent pure, was used in part for denaturing alcohol where a refined benzol is not required. Some was used direct for the production of phenol, the 9 per cent of paraffins present being removed after the benzol was sulphated. Some of the benzol was blended with three to four volumes of pure benzol obtained from light oil, and after blending was used as pure benzol.

The disposition of the toluene was not so easy. Of course, the toluene was intended for the manufacture of trinitrotoluene (T. N. T.). In the nitration of toluene containing paraffins, the paraffins present are in part polymerized and in part oxidized, but the resultant polymerization and oxidation products remain dissolved in the T. N. T., which necessitates recrystallization of the product. Indeed, direct nitration of the so-called "Rittman toluene" proved so hazardous that resort was made to blending the toluene with pure toluene from other sources. The T. N. T. thus obtained was so contaminated that blending had to be abandoned because otherwise passable T. N. T. was thereby rendered so impure that the entire lot had to be subjected to expensive recrystallization. Another method used for eliminating paraffins consisted in dissolving the mononitro-toluene first produced in 66-deg. sulphuric acid. After solution in the acid a large part of the paraffins

present separated as a layer on the sulphuric acid solution of mononitro-toluene. Much of the paraffins, however, even in the mononitration stage, were polymerized and seriously injured the product. Purification of the mononitro-toluene by distillation, as recommended by Dr. Rittman in his published description of the method, was never attempted on a large scale because of the danger attending this operation when such an impure nitrotoluene is distilled.

Over a long period of time the cost of producing benzene and toluene by this process was far in excess of the prices ever reached during the unparalleled period of high prices in 1915. The writer insists that soft coal is the most economical source of supply of benzene and toluene.

Corrosion

Corrosion of Tinned Sheet Copper.—The results of an investigation on the structure of tin coatings on copper are given in Technologic Paper No. 90 of the Bureau of Standards. The author is PAUL D. MERICA. The paper includes some interesting microphotographs. The attention of the author had been directed to a curious case of local corrosion or pitting in tinned sheet copper roofing. The pits occur in general along the line of surface scratches, having appeared some eight or ten years after completion of the roof. These pits are apparently unrelated to the service conditions and to the direction of rolling of the sheet. When the copper becomes exposed, as in the present case at the bottom of the scratches on the surface, it forms together with the alloy layer a galvanic couple, electrolytic action sets in, and the copper at these points is corroded, forming the pits described. This publication gives the results of a study on the structure of tin coatings on copper and it is shown that this coating consists of at least three layers, viz., a thin layer of Cu, Sn immediately next to the copper, then a layer of Heycock and Neville's constituent H, containing about 60 per cent by weight of tin, and finally a layer of the eutectic of tin and copper, in which is found most probably also the lead when it is present in the tinning mixture. Etching experiments and measurements of the electrolytic e.m.f. have indicated that these intermediate layers are electronegative to both the outer tin (eutectic) and the underlying copper itself (by from 5 to 50 millivolts), and less readily attacked by water and dilute acids (also alkalis). This is true also of tin coatings, containing lead, and holds not only for the corroded sheet examined, No. 1054, from the roof of the Library of Congress, but for all others examined, including several direct from the manufacturers. The results explain the local character and type of corrosion exhibited by the sample 1054. The coating is very thin and also quite variable in thickness and structure. The surface scratches have exposed the copper at various points. This exposure of the copper along these scratches is aided by the fact that the adjacent alloy layer is extremely brittle and readily torn or crumbled out. As long as the tin eutectic layer was present it has, owing to its greater corrodibility and electropotential, been first attacked, thus protecting the copper. Finally, however, after several years this layer has been almost wholly removed, and at those points where the copper is exposed the attack has set in, the copper, forming with the adjacent electronegative alloy layer a galvanic couple, of which the copper is attacked and eaten away, forming the pits as described above. The same thing happens at the points where, as has been shown, there is a break in the continuity of the alloy layer. Here the eutectic layer is corroded off, exposing the copper at once, the latter being corroded in similar manner as above described. It would thus appear that whenever the outer tin or eutectic layer of a tin coating

on copper is removed the alloy layer remaining gives only a mechanical protection from corrosion—that is, it does not protect the underlying copper electrochemically, as does zinc, iron in galvanized products. Corrosion of the type described, therefore, should be possible in any tinned copper material. Yet instances are known of tinned copper roofs, which have stood up for 20 to 25 years under apparently more severe service conditions without showing sign of any such pitting as has been described. For the variation in resistance to corrosion of different samples of this material many factors might be responsible. First and foremost is the question of the mechanical abuses received, such as scratching and indenting. This has been shown to be the determining factor in the case described. A sample of the roof from the Statehouse in Texas showed absolutely no scratches; this roof has resisted corrosion for twenty or more years. The other principal factor is undoubtedly that of the thickness and uniformity in structure of the coating. This varied quite noticeably in the various samples examined. The corroded sample, 1054, showed perhaps the greatest degree of nonuniformity in this respect. A third factor which must not be lost sight of in this connection is that of the electrolytic solution potential of the base copper itself. Experiments have shown that this may vary for different samples within several millivolts, a range which is of the same order of magnitude as that of the difference in electromotive force between the copper and the tin-copper alloy.

Chemistry and the War in Germany

Solving of Wartime Problems in Germany.—In the *Journal of the Society of Chemical Industry*, March 31, 1917, is given a review of some of the problems encountered by Germany since the war started, and how they have been solved. The information was obtained from the German technical journals. Most of the national wants have been foreseen long before they occurred, and whenever it has been possible the chemist has found a substitute, although not always an efficient one. Early in 1914, Germany foresaw that the struggle upon which she had then determined would be essentially a petrol war, and that every gallon of petrol would be required by her fighting services, and so the outbreak of the war found all the motor vehicles in Berlin, down to the taxicabs, provided with engines adapted to consume either petrol or alcohol. As some difficulties were experienced in using alcohol by itself, systematic experiments were made with mixtures of alcohol with benzene and other hydrocarbons, and the formulæ giving the best results were published in the chemical journals.

The first plant for the fixation of nitrogen from the air was established in Germany not many months before the war, and at the present time the bulk of the nitrates required for the manufacture of her explosives is derived from that source. Nor is this the only direction in which nitrogen obtained from the air has been utilized. With the increasing strictness of the British blockade it became essential to discover a substitute for nitrogenous feeding-stuffs for horses and cattle, about 500,000 tons of which had been imported prior to the war. To meet this deficiency it was suggested to the authorities that a special yeast, which had a vigorous growth, but produced no alcohol, should be cultivated and pressed on a large scale. This work has been carried out under the direction of the Institute of Brewing in Berlin. Enormous shallow tanks, like swimming baths, have been erected, and in the bottom of these are fitted pipes to maintain the optimum temperature for the growth of the yeast, which is cultivated in a medium prepared from refuse material from the sugar works

mixed with suitable salts, including ammonium salts obtained synthetically from the air. The compressed yeast is stated to be suitable not only as a nitrogenous fodder, but also for human food. It is estimated that before long Germany will be in a position to obtain from this source the whole of the nitrogenous fodder she requires, and that she will never again be dependent upon the outside world for her supplies.

In connection with feeding-stuffs it is significant that attention should at once have been directed to the utilization of kitchen refuse. Within two months after the outbreak of the war a notice was issued by Prussian municipalities that all householders were required to sort their kitchen refuse. All fatty material was to be kept separate, while the vegetable material was to be saved for fodder. As subsequently organized, more especially in the larger towns, it was prescribed that the fatty material should be taken to specified soap works, where the glycerin was to be separated and the soap returned to the householder. No one is allowed to make any soap privately.

One difficulty in dealing with the vegetable matter was the necessity of drying it quickly to prevent putrefaction, and it was suggested that the waste heat of the gas works should be utilized in this way, although subsequent issues of the journal do not state whether this has been done. Still more recently attention has been directed to the annual loss of potatoes by disease, and it is suggested that frost-bitten or diseased potatoes should be dried and used as an ingredient of fodder, or that they should be used in the preparation of starch. While Germany has been making use of kitchen refuse in this way for over two years it is only within the last month that any proposal to prevent this loss in England has been put forward.

The lack of oils and fats has been Germany's greatest difficulty and she has only been able to supply her wants of nitroglycerin at the expense of the health of the community. Hence the chemical papers have constantly published the results of the analyses of little-known home-grown seeds, which have never before been regarded as possible sources of oil. It has been shown that asparagus and other vegetable seeds contain a considerable proportion of oil, though it is doubtful whether they would repay the labor of extracting it. In two cases, however, the suggestion of the chemist has borne fruit. Horse-chestnuts are now systematically collected both for the separation of the large amount of oil which they contain, and for the preparation of a saponin extract to take the place of soap; while in Southern Germany the National Women's Guild has made itself responsible for the collection of the enormous quantities of cherry stones, which were previously thrown away. These are crushed and the kernels separated by an ingenious method of treatment with a solution of a salt of such specific gravity that the kernels float on the surface while the shells sink. The kernels are then dried and the oil expressed in the usual way. By means such as these Germany has made great additions to her supplies of oils, but the deficiency is too great to be materially alleviated by any device short of the synthesis of fat.

Mention might also be made of the various detailed experiments which have been carried out to discover palatable substitutes for tea, coffee, and cocoa, and of those upon which the composition of the so-called war-bread has been based. In every direction the German places himself in the hands of the expert chemist, and it is only the lack of raw material in certain essential particulars, which has prevented the chemist from solving every material difficulty with which Germany is now face to face.

Recent Metallurgical and Chemical Patents

Electric Furnaces

Electric Calcining Furnace.—A continuous electric furnace for heating coal, petroleum-coke, etc., to high temperatures for use in the manufacture of carbon articles, is patented by WILLIAM R. CLYMER of Lakewood, Ohio. The patent is assigned to the National Carbon Company of Cleveland, Ohio. A cross-section of the furnace is shown in Fig. 1. It is composed of three main parts; a water-cooled conveyor 1, an electric furnace, and a preheating chamber 3. In starting the furnace for continuous operation, material such as petroleum-coke is first fed into the hopper 60, until the preheater and electric furnace are filled to the extent indicated in Fig. 1. At this height no more material

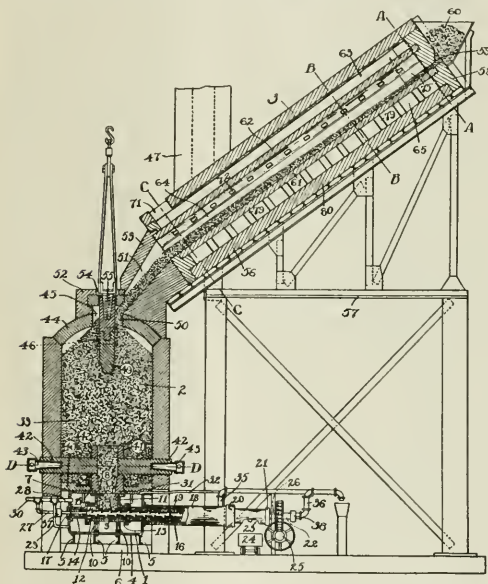


FIG. 1—CROSS-SECTION OF CALCINING FURNACE

will be removed from the hopper until some of the charge is removed at the base of the furnace. The heating is then commenced by blowing in a mixture of air and oil or gas, and burning the mixture until the charge in the preheater has been heated to a certain extent. When combustion has been started in this manner the conveyor screw will be rotated to cause a continuous passage of material through the entire apparatus. Since the original charge has not been properly heated, it will again be fed into the furnace or otherwise disposed of. As soon as the preheated charge reaches the electric heating region the electric current is turned on and the material is heated up to the desired temperature. The material is delivered to the electrical part of the furnace at a temperature of 1000 to 1200 deg. C. For this reason much less current is needed than in types of electric furnaces where the material is heated from room temperature to 2000 deg. C. The gases from the coke itself are utilized to preheat the material. The output of the furnace described is 1000 to 2000 lb. per hour (1,223,475, April 24, 1917).

Electric Furnace Electrode.—A carbon electrode with a coating of a mixture of fire-clay and graphite is patented by JESSE C. KING of Montreal, Canada. The

coating, which for ordinary purposes consists of fifty parts graphite and fifty parts clay by weight, is placed on the carbon electrode while the same is in the plastic condition. The whole is then baked to drive off the moisture and harden the electrode and its coating. The purpose of coating the electrode is to make it impervious to oxidation by gases, which would shorten its life (1,223,986, April 24, 1917).

Blast Furnace with Auxiliary Electric Heating.—A blast furnace for iron or other metals, having bottom and top electrodes in addition to the regular equipment, is patented by HENRY M. CHANCE of Philadelphia, Pa. A cross-section of the furnace is shown in Fig. 2 in which 1 indicates the shaft wall of the furnace, equipped with charging bell 2, 3 indicates the bosh of the furnace, 4 the blast twyers, 5 the crucible of the furnace provided with a slag tap 6 and metal tap 7. One or

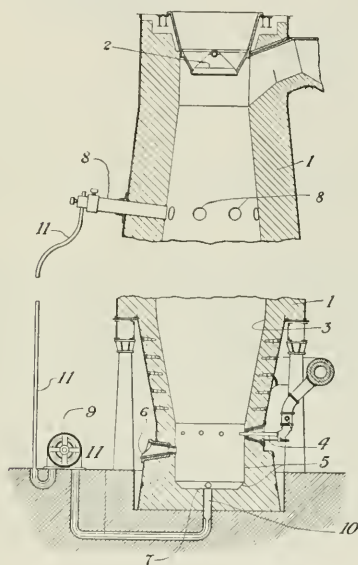


FIG. 2—CROSS-SECTION OF FURNACE

more conductors, or electrodes, 8, project through the furnace wall and are electrically connected by conductors 11 through a source of electric energy 9 with electrode 10, which passes through the wall of the crucible 5 and thus is in electrical contact with any metal contained in said crucible. In smelting iron ore, the furnace is charged as usual with ore, coke and limestone and smelted by blast. When sufficient slag and molten metal have been formed, the electric current is turned on. Electrolytic action as well as heat is claimed to aid in the removal of impurities from the molten metal (1,221,139, April 3, 1917).

Oil Cracking

Oil Cracking Apparatus and Process.—An electric-furnace cracking process is patented by LEON E. HIRT of Charleston, W. Va. A cross-section of the apparatus is shown in Fig. 3. Oil from the tank 7 is pumped up through pipe 12 to atomizer 13, where dry steam from pipe 13 atomizes the oil. The spray formed passes down through the expanded section of the furnace 3, and through the electrode region 4, where it is broken up into various constituents. The fractions obtained pass out through valve 16, which controls the pressure in the furnace. Any uncracked oil is trapped back into the

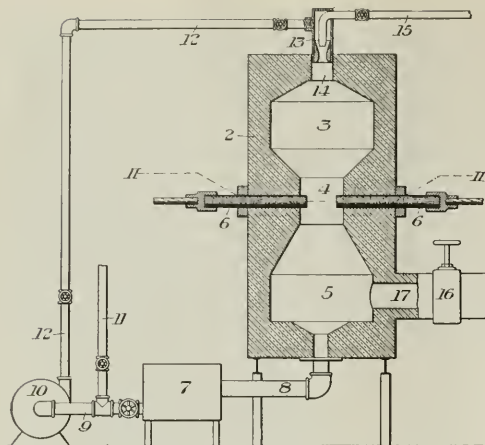


FIG. 3—ELEVATION OF CRACKING APPARATUS

tank through pipe 8. The furnace is cylindrical and is designed to operate either under pressure or vacuum (1,222,402, April 10, 1917).

Alloys

Use of Zirconium in Alloys.—Alloys based on the use of zirconium are patented by HUGH S. COOPER of Cleveland, Ohio (assigned to the Cooper Company of Cleveland, Ohio). Metals such as cobalt or nickel are hardened or toughened by adding varying percentages of zirconium. The product is also resistant to acids and alkalis and has a high electric resistance. When heated to 1150 deg. C. a protective oxide coating is formed on the outside. An alloy of 2 to 10 per cent zirconium, and the balance nickel, is stated to take a fine cutting edge. With 8 to 15 per cent zirconium and the balance nickel or cobalt the melting point of the alloy is decreased below that of nickel, or about 1400 deg. C., and the electrical resistance increased. With 16 to 30 per cent of zirconium the hardness is greatly increased and is useful for cutting tools. The melting point and tensile strength are lowered by increased amounts of zirconium, and the alloy cannot be worked by ordinary methods involving forging, drawing and rolling, but may be cast to produce lathe or cutting tools for working alloy steels, drill rod and bronze. The alloys can be made from zirconium ore, one grade of which contains about 73 per cent of oxide. An aluminothermic method is used.

If it is desired to raise the melting point considerably, molybdenum is added. It is claimed that these alloys have the peculiar property of self-hardening and are ready for use when casted; that is, no treatment is necessary before use nor are they improved by any tempering process known. The alloy takes a beautiful polish which is not affected by gases of the atmosphere, nor corroded by alkalis or cold concentrated nitric, sulfuric, hydrochloric or boiling sulfuric acids, or cold dilute acids (1,221,769, April 3, 1917).

Aluminium-Soldering Compound.—A compound for soldering aluminium is patented by CHARLES A. STEWART of Carson City, Nev. The compound is an alloy of 69.07 parts tin, 28.77 parts lead, 1.44 zinc and 0.72 parts silver. These metals are melted together in the above proportions and the melt cast into sticks or rods for commercial use in aluminium soldering (1,222,158, April 10, 1917).

A Combined Steam Turbine and Centrifugal Boiler Feed Pump

The displacement of the reciprocating boiler feed pump by the centrifugal pump furnishes a good example of the necessity resting upon manufacturers of machinery for sustained technical development. The duplex boiler feeder, considered an improvement at the time of its introduction, some 50 years ago, because of its simplicity and more uniform delivery, was eventually taken up by numerous manufacturers, each of whom developed a complete line. The type became standardized, so that competition was close and severe. A comparison of the closely printed tabulations of sizes and models of duplex pumps, as catalogued by the dozen or so builders, will indicate the immense amount of money that was invested in drawings, patterns and manufacturing equipment, all now rendered practically obsolete, or at least greatly depreciated in value, by the perfection of the more compact, simple, reliable and efficient steam turbine-driven centrifugal boiler feeder.

Since it must handle a comparatively small amount of water against a relatively great head, the centrifugal boiler feeder should be fitted with small-diameter impellers running at high speed. It is therefore well adapted for steam-turbine drive.

In Fig. 1 is shown a 3000-hp., two-stage centrifugal boiler feeder combined in one casing and on one shaft with a velocity-stage steam turbine. This unit, which has been developed by the De Laval Steam Turbine Co. of Trenton, N. J., weighs only about one-tenth as much as a duplex reciprocating pump of the same delivery, and occupies only about one-eighth as much floor space and one-fifteenth as much cubical space.

The pump end contains two single-suction impellers, cast from a special bronze and carefully finished to exact contours. Two impellers are used for pressures up to 200 lb. per square inch, and three impellers for higher pressures. Single-stage boiler feed pumps have been built, but two or three stages are preferable because of the much longer life of the impellers at slower speeds. Each impeller discharges into a volute chamber by means of which the velocity in the water as it leaves the impeller is converted into pressure before the water is led to the eye of the succeeding impeller. This means of energy conversion is superior to the use of diffusion rings, as it is efficient over a wide range of delivery; and, more important still, does not involve the use of small and sharp parts like diffusion blades, which are subject to rapid erosion.

The pump is hydraulically balanced, and only one

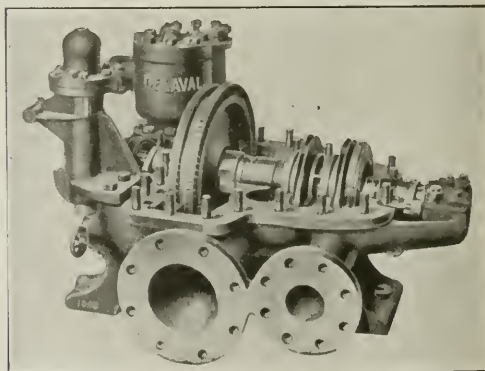


FIG. 1—CENTRIFUGAL PUMP WITH CASING REMOVED

pair of labyrinth rings surrounding the suction opening is required for each impeller, except the last, which has two sets of rings. The whole back of the impeller is subjected to a pressure equal to that existing at the periphery of the impeller, the same pressure acting on the front of the impeller, except for the area of the circle enclosed by the labyrinth ring about the suction opening. The last impeller, that is, the one from which the water is finally discharged, is equipped with two sets of wearing rings, one on the suction side and one on the reverse side of the web. As some water from the discharge of this impeller will leak between the wearing rings into the space back of the web, this impeller would be equally as unbalanced as the other impellers in the pump if there were no escape for the leakage water. To provide for diminishing the pressure in this balancing space as much as may be required to bring the whole series of impellers into balance, a leakage outlet is provided from which water can be conducted back to the suction of the first impeller.

The outlet leakage takes place between two collars, one attached to the casing and the other carried on the shaft. When the shaft moves toward the discharge end of the pump this escape is closed off and the pressure builds up in the balancing chamber. If the shaft, on the other hand, moves toward the suction, this escape passage is opened wider, allowing the pressure in the balancing chamber to fall and at the same time the in-leakage between the labyrinth wearing rings is decreased. By this means direct and positive balancing within very close clearance is secured with leakage of but a small amount of water. The so-called natural balancing secured by the use of double suction impellers in a multi-stage pump, is, in comparison, uncertain and imperfect, besides involving an extra long shaft, heavier impellers and two pairs of wearing rings to each impeller.

The labyrinth wearing rings are readily renewable, the stationary ring of each pair being held in a seat in the casing and the rotating ring being screwed upon the impeller. The reduction of leakage secured by the use of intermeshing labyrinth rings is highly important for securing high efficiency in pumps of comparatively small delivery. With the labyrinth type of ring the leakage path is so tortuous that very little water escapes even at high heads, although ample clearance is provided to take up expansion and contraction due to changes in temperature.

The suction end of the pump is adjacent to the turbine, and the shaft packing between the turbine and pump chambers is hence subjected to turbine exhaust pressure on one side and the suction pressure on the other. A simple packing is therefore sufficient, and in any case any small leakage of steam in one direction, or of water in the other, does no harm. As the leakage space adjacent to the balancing chamber at the discharge end of the pump is connected back to the pump suction, the packing about the shaft is subjected only to suction pressure. Aside from the intermediate packing already mentioned there is only one steam packing, which is subjected to exhaust pressure.

The steam end of the unit consists of a velocity-staged turbine with either two or three rows of moving buckets, according to the steam economy desired. The nozzles can be proportioned for either high-pressure steam exhausting to feed heater, or to condenser for low-pressure steam exhausting to condenser, or the unit can be made interchangeable, thus permitting of a great degree of flexibility in plant design. Where the exhaust steam from the boiler feeder is consumed in heating feed water the thermal efficiency of the turbine-driven boiler feeder is much greater than that of a

boiler feeder driven by electric motor, or even than that of the main unit itself.

The unit is ordinarily fitted with a speed governor mounted upon the end of the shaft, and when running at constant speed the head varies with the delivery, as shown by the curved characteristic in the accompanying chart. As will be seen, the rise in pressure at reduced capacity is not excessive. Ordinarily, however, a pump governor controlled by the pressure at some point in the feed line near the boilers is employed to control the speed, giving a practically uniform pressure at all deliveries, as shown by the lower and straight line in the chart. In case of failure of the pressure governor to operate, the control of the unit is automatically taken over by the speed governor.

However, to provide against any possibility of racing, an emergency governor is also fitted. This consists of a pin contained within a hole bored diametrically through the shaft. This pin is held by a spring from flying out under the influence of centrifugal force. When the speed reaches a certain point the spring is compressed so that the pin strikes a trip, releasing another spring by which the governor valve is closed at once and completely. Racing and excessive overpressure are therefore impossible. The normal speeds of these pumps vary from 1800 to 3500 r.p.m., according to pressure and capacity, and, due to the heavy shafts employed, are far below the critical speeds.

The bearings are of the straight, ring-oiled type, and, like other parts subject to wear, such as the pump impellers, turbine rotor labyrinth rings, and governor valves, are built to a limit-gage basis, so that they are all interchangeable. The entire rotating members and all wearing parts, with the exception of the governor valve, are accessible for inspection or removal upon lifting the casing cover and taking off the bearing caps, all of which can be done without breaking steam or water-pipe connections.

In specifying the capacity of boiler feeders, the temperature of the water to be pumped should always be stated, as the capacity is nearly 50 per cent greater with water at 75 deg. F. than with water at 210 deg. F. For the same reason, capacity and efficiency tests of a pump should be carried out with water at the temperature at which it will be received by the pump when in actual service.

Survey of California's Resources.—The State Mining Bureau of California under the direction of Fletcher Hamilton, State Mineralogist, is starting a field campaign to report on the economic minerals of California which have an important industrial and military bearing on the present war situation. For the past four years the Bureau has been working on a complete survey of the entire State's mineral resources by counties, field work for which is now practically completed and the results in part published. Particular interest and value attaches at the present moment to the available supplies of chrome, coal, iron, magnesite, manganese, molybdenum, quicksilver and tungsten. The extent and availability of the petroleum resources, which are so important in modern naval operations, have already been thoroughly covered by the Bureau in its work of protecting the fields from damage by faulty operations. As data on the other minerals are already well in hand, trained geologists and engineers of the Bureau's staff are being sent out to bring the information down-to-the-minute with relation to the latest developments in the above-named items. The report will cover the location, size, accessibility to transportation, character, quality, and state of development of every known deposit throughout the entire state.

New Design of Dust Collector

The elimination of dust from hot flue gases has been difficult, and has received a great deal of attention during the last few years. There have been many dust collectors developed, and the electrical precipitation method has also been adapted to many dust and fume-collecting problems.

In the ordinary type of dust chamber, where baffles are used, a velocity not exceeding 5 ft. per second has been found the best for settling dust. The majority of dust chambers have not been found efficient, as there is always a certain amount of current in the gas which keeps the finest particles in motion and carries them beyond the chamber. Various methods have been used: hanging wires, horizontal plates, inverted half cylinders, etc., where the dust built up due to the large obstructing area, but without entirely stopping the current of air.

A dust collector patented Jan. 2, 1917, by Wm. Robertson, has several novel and interesting features. The gas passes over troughs which form a "dead air space," and it is claimed that the dust falls with no current to disturb it and carry it along. A cross section of the apparatus is shown in Fig. 1.

The gas enters at the top at the left where marked "inlet," and passes down around the trough-shaped baffles. When gas is passing through the chamber these baffles are closed, as shown at the right. The dust which falls in the dead air space above the troughs, is collected in the troughs, and these are emptied periodically by lowering one side of the trough, as shown at the left. This is one of the interesting features of the

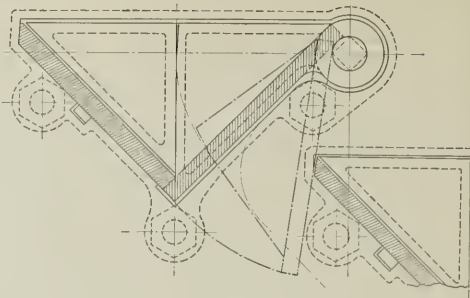


FIG. 2—DETAIL OF DUST TROUGHS

collector, and a detail of the trough is shown in Fig. 2.

As shown in this drawing, the right side of the trough is lowered and strikes the left side of the adjacent trough, thus helping to knock off the dust which might cling to the trough. By opening a whole vertical set of troughs at one time a free path is formed for the dust to drop to the bottom. One section of the chamber is closed and gas passes through while the other is open for emptying.

The dust can be removed from the bottom by a screw conveyor.

An end view of the chamber is shown in Fig. 3. At the left is shown a wheel for emptying the troughs. The design has later been modified so as to have the emptying done by lever in order to get a quick drop and the consequent knocking effect, and each ver-

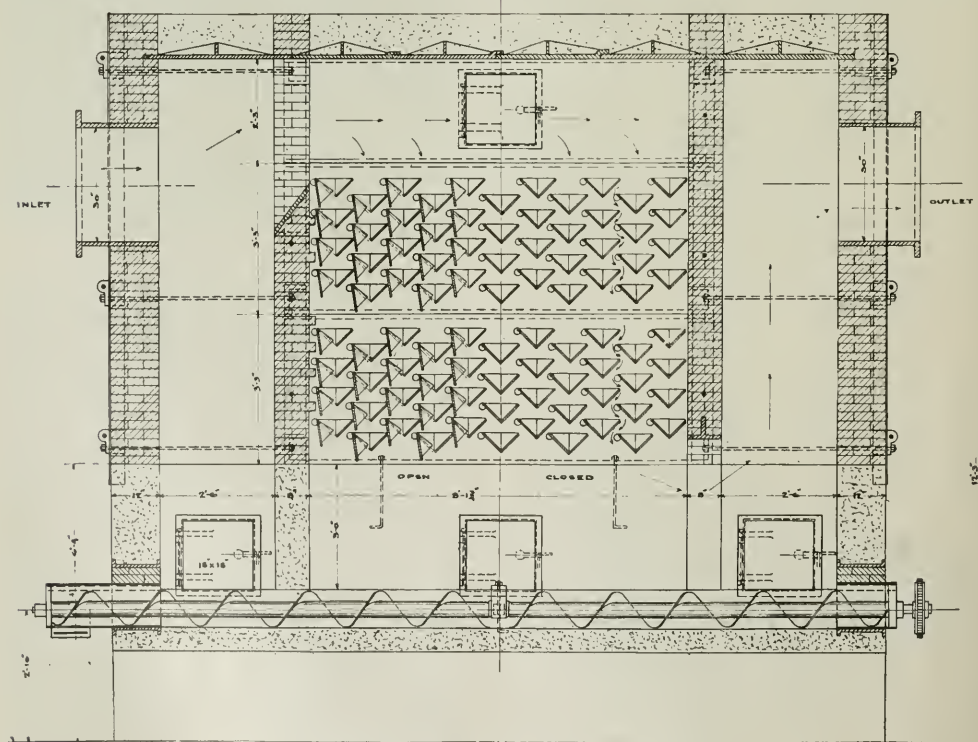


FIG. 1—SIDE ELEVATION OF ROBERTSON DUST COLLECTOR

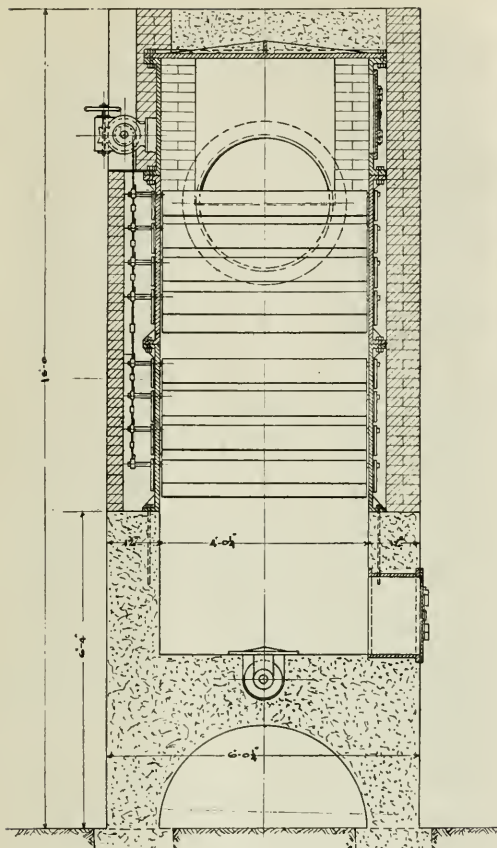


FIG. 3—END VIEW OF ROBERTSON DUST COLLECTOR

tical row of troughs is operated by a separate level.

The chief features of the collector are the "dead-air space," the easy dumping methods and the trough design of the baffles.

New Foundry for Iron and Steel Castings

The Lunkenheimer Company of Cincinnati, Ohio, manufacturer of high-grade engineering specialties, has recently added to its plant a new foundry and pattern shop for the casting of products made of ferrous materials.

The new foundry occupies an area of 36,000 square feet and the pattern storage building an area of 18,000 square feet, the latter building being four stories in height. Both the buildings are of reinforced concrete. Provision has been made to add two more floors to the pattern storage building and the wall at one end of the foundry is so built as to enable easy removal to further extend this building when more space is required. Excellent light and ventilation is afforded by the saw-tooth roof construction of the foundry together with the large number of Fenestra windows used. A sprinkler system has been installed and wherever possible fireproof material is used throughout the building. The floor of the foundry building is of creosoted wood block which is stated to make an excellent smooth surface, exceptionally durable and easily repaired. A wash room for the employees adjoins the foundry. A sufficient num-



GENERAL VIEW OF FOUNDRY

ber of shower baths are also provided for the employees and all have their own steel lockers.

For the melting of iron, a cupola having a capacity of ten tons per hour is used. The molten metal is poured from the cupola into large crucibles mounted on wheels which are pulled on rails to the destination intended. These large crucibles can be tilted in order to fill the small ladles used in pouring the metal in the molds. Compositions of other ferrous materials are melted in revolving furnaces of the company's design.

Six traveling cranes, the majority of which are electrically operated, are provided for handling the heavy work, and all appliances necessary for the efficient operation of an up-to-date foundry are present and arranged in systematic relation to each other.

Directly in the rear of the foundry is a railroad from which a spur is run to a concrete storage house in which sand, coke and other materials are kept.

In order to save time a large part of the material and machinery was moved from the old foundry building to the new one, a distance of about a city block, during the period from Saturday noon, March 24, to Monday morning, March 26, thus enabling many molders to continue their work without loss of time.

Book Reviews

Blast Furnace Construction in America. By J. E. Johnson, Jr. 415 pages, 247 illustrations. Price, \$4 net. McGraw-Hill Book Co.

Probably no living person is qualified for so many different reasons to write a book on this subject as is J. E. Johnson, Jr. His father was an important American ironmaster and this author may be said to have been born and bred around a blast furnace. For more than twenty years he has held a prominent position as operator, inventor, author, and interpreter. Two of his achievements in the latter capacity would alone be sufficient to place him in the first rank of modern scientific interpreters; namely, his theory of the constitution of cast iron, which has since been expanded and elaborated by himself and others, and his theory of the critical temperature of the blast furnace, which is now generally accepted as the explanation of the saving effected by drying blast, which was once considered (especially by German theorists) as super-theoretical and, therefore, impossible. A deep thinker, the author nevertheless uses exact and clear language, which makes the text easy reading for everyone and within the grasp of any intelligent furnace man.

This volume deals chiefly with the mechanical side of the blast furnace and will be followed by another book treating the subject from the metallurgical viewpoint. This book would be correctly classified as a book of reference, because of the comprehensive nature of the contents and the detail into which the text enters, but it is also suitable for use as a textbook for students or practitioners wishing to acquire a thorough knowledge of the subject. The contents include fundamental conditions, definitions, classification, handling of the raw materials and products, mechanical equipment, such as boilers, blowers and hoisting apparatus, water supply system, pumps, electric supply and so forth; also a comprehensive study of hot-blast stoves and the construction of the stack.

A chapter is devoted to each of two very important subjects, namely, The Cleaning and Washing of Gas and the Drying of Blast, including a critical study of the different processes for drying with, a glimpse into the future and the advantage of the different systems.

The book is strongly recommended to every blast furnace man and to those interested in blast furnaces.

BRADLEY STOUTON.

* * *

The Founder's Manual. By David W. Payne. Octavo (11 x 19 cm.), xi + 676 pages, 245 illustrations, flexible black morocco binding; price \$4.00 net. New York: D. Van Nostrand Company.

The author, editor of *Steam*, with many years' foundry experience, compiles a great mass of information scattered through technical journals, transactions of societies, and special books. A preliminary portion of the book, intended largely for beginners, relates to elementary mathematics, mechanics, etc., taken from standard text-books and trade publications. The remainder, the foundry part, contains a vast amount of information, not very carefully selected and not logically arranged.

Much of the tabular information is quoted from old books and contains inexact or even grossly erroneous data; e.g., the boiling point of sulphur given as 570 deg. Fahr. instead of 833 deg.; melting point of mercury 39 deg. Fahr. instead of -39 deg.; latent heat of fusion of aluminium 28.5 instead of 90; the combining equivalents of the elements given as so many degrees centigrade (!) (H = 1 deg. C., O = 8 deg. C., etc.).

Aside from these unreliable tables, the practical information on all phases of foundry practice and its supplementary arts is at places very good and at others misleading or incomplete. Those so expert in physics, chemistry, metallurgy and foundry practice that they are safe from being misled by the misinformation so liberally sprinkled throughout it, will be able to make good use of those portions of the book which are indeed very good.

* * *

Annual Chemical Directory of the United States. Edited by B. F. Lovelace. 365 pages. Cloth. Price \$5, postpaid. Baltimore: Williams & Wilkins Company.

This is the first appearance of a separate chemical directory which has aimed to cover the entire field of products, equipment, institutions, societies, publications and engineers. A very good attempt has been made in this book to collect and classify information which should prove very useful as a reference work. It is the intention to issue it once a year.

The first chapter contains a list of American manufacturers and dealers in chemicals. The companies are listed under the products alphabetically by states. The compilation of such a list is a laborious and difficult task and it can hardly be expected to be com-

plete. The compiler should have the assistance of all the manufacturers and dealers in order to make the list as complete as possible.

The second chapter contains a very good list of manufacturers of and dealers in apparatus and equipment for plants and laboratories. The information is carefully indexed and covers 105 pages. Some of the items such as abrasives and acetylene gas, it would seem more logical to list under the products in Chapter I.

Chapter III contains a list of analytical chemists, consulting chemists, and chemical engineers. There is room for considerable improvement in this chapter. The list of consulting chemists is surprisingly incomplete, as is also the list of chemical engineers, which consists mostly of equipment manufacturers. Many firms and individuals are listed only as analytical chemists which also belong in the other lists. It would seem more logical to combine the headings Consulting Chemists and Chemical Engineers under one heading, as the distinction is not clear. Or if the distinction is to be kept up, exact definitions of consulting chemists and chemical engineers should be given.

In Chapter IV there is another heading, Industrial and Professional Laboratories. It would seem that there is duplication here with Chapter III.

The American and foreign colleges and universities offering courses in chemistry are listed in Chapter V. This is a splendid idea and is something that should prove very valuable. It would be still more valuable if it were possible to state under each college whether or not the course includes chemical engineering.

The list of experiment stations in Chapter VI seems to include only agricultural stations. This should include many other engineering experiment stations which carry on chemical investigations and also the Bureau of Mines stations.

The remaining chapters contain lists of Federal officials of dairying, food, drugs, health and feeding stuffs bureaus, technical and scientific societies and journals, and a few pages of chemical developments in 1916. The last-named department seems superfluous in a work of this kind and it would seem more desirable to bring the other departments up to a higher standard rather than try to do too much. The authors and publishers are to be congratulated on their efforts to do something worth while for chemistry in this country, and it is to be hoped that they will receive much co-operation in the preparation of subsequent editions.

* * *

Operation of Gas Works.—By Walter M. Russell. Octavo (15 x 23 cm.), 209 pages, 76 illustrations. Price, \$2.00. New York and London: McGraw-Hill Book Company, Inc.

This is a book describing ordinary American practice, for the use of a foreman, superintendent, engineer or cadet, in a small or medium-sized gas works. It is not accurate or scientific enough, or sufficiently up-to-date, for the use of anyone connected with a large, modern plant. The chemical explanations are weak, but the details of practical management are good. Within the limits noted the book has a mission.

Bureau of Mines Station at Golden, Col.—The equipment and installation of the technologic laboratory at Golden have been almost completed. The laboratory is designed to handle rare metal ores in quantities from 10 lb. to 500 lb. It is designed to make any kind of acid leach; any kind of an alkaline or salt leach, and any kind of a fusion. In addition a small wedge type roasting furnace has been installed as well as a tube furnace which can be used either for oxidation or reduction.

Personal

Prof. G. H. Clevenger of Leland Stanford University, California, has been appointed research professor in metallurgy and will relinquish his elementary and routine teaching.

Mr. R. E. Conder of the Boston Woven Hose and Rubber Co. gave a talk on the manufacture of rubber and its products before the Technology Club of New York on Friday evening, May 25. Mr. Conder also showed some interesting moving pictures.

Mr. James F. Couch was elected president of the recently organized Des Moines Chemical Society at the regular meeting on April 9.

Messrs. A. E. Drucker and G. W. Laurie have opened an office at 30 Church Street, New York, as consulting metallurgical engineers under the name of Drucker & Laurie.

Mr. John F. Hale, for eleven years assistant manager of Warren Webster & Co., Camden, N. J., and for nine years previously vice-president of the Consolidated Engineering Co., Chicago, is now with the Braemer Air Conditioning Corporation of Philadelphia in an official capacity. Mr. Hale was a former president of the Society of Heating and Ventilating Engineers.

Mr. F. A. Lidbury, manager of the Oldbury Electrochemical Company, Niagara Falls, N. Y., was elected president of the Engineering Society of Buffalo at a meeting held Wednesday evening, May 9.

Dr. H. N. McCoy, who has been connected with the chemistry department of the University of Chicago since 1901 and professor since 1911, has resigned and will devote his time to his important technical interests. His process of extracting radium from carnotite is being used by the Carnotite Production Company of Chicago, in which he is a director. He is also interested in the production of thorium and related products and is a director of the Lindsay Light Company of Chicago, large producers of thorium.

Mr. Guilford D. Scholl, formerly with the United States Metals Refining Company, the Electrolytic Refining & Smelting Company of Australia, Ltd., and the experimental leaching and electrolytic plant of the Copper Queen at Douglas, has resigned as construction superintendent for the Walter E. Lummus Company of Boston, Mass., to become superintendent of the electrolytic zinc plant of the River Smelting & Refining Company, at Keokuk, Iowa.

Messrs. W. H. Seagrave and W. E. Dunkle, consulting engineers, have recently formed a company to be known as W. H. Seagrave Company, with offices in the L. C. Smith Building, Seattle, Wash. Both members of the firm are well-known mining engineers, Mr. Seagrave having been the manager of the Kennecott Copper mines of Alaska, and Mr. Dunkle the field geologist and traveling representative of the Alaska Syndicate.

Mr. A. R. Topping has been elected secretary of the Walter A. Zelnicker Supply Co. of St. Louis, Mo. He has been associated with the company for the past eleven years.

Mr. Thomas Varley, flotation expert of the U. S. Bureau of Mines, has recently visited the Seattle station of the Bureau of Mines and College of Mines of the University of Washington. A thorough inspection of the equipment of the college laboratories has been made, to be used by the local station in research work.

Mr. Ernest Wittenau has been appointed assistant-superintendent of concentration at Clifton and Morenci for The Arizona Copper Co., Ltd.

CURRENT MARKET REPORTS

The Iron and Steel Market

While the steel market has given no patent exhibition of its being on a new tack there is every reason to believe that a new order of things marketwise is arriving. Advances in finished steel prices in the past two or three weeks have been relatively unimportant. While such a short period does not furnish a criterion, since throughout this movement there have been spurts in price advances, interspersed with periods of a few weeks of almost stationary prices, the character of the business being done, and the attitude of both buyers and sellers, is suggestive that the steel market is entering a new period.

The tonnage of steel business being entered on order books is no doubt, roughly speaking, equal to the output in shipments against old orders, but the character of the business is changed. There is less business in the form of specific orders, for a given purpose, and more in the form of the ordinary open contract, subject to future specification, this buying being by jobbers and ordinary manufacturing consumers. It is to be presumed that in the event of a break in prices the contracts would be adjusted to suit the conditions.

It is characteristic of the American steel market that it is difficult for it to remain at a fixed level for any length of time, unless perchance the level is one fixed by the cost of production, and that when prices cease advancing they begin to get weak. The market is strong only when it is advancing. After a period of advances the existing contracts are at less than the then current market rates and buyers continue to receive their shipments because the steel is cheaper than what could be bought in the open market. On an average, the current deliveries of finished steel products are at between \$20 and \$30 a net ton below the present market rates for forward deliveries.

Assuming the difference is \$25 a ton, and observing that since March 1 steel prices have been advancing at an average rate, to set it conservatively low, of \$6 a ton, a continuance of this rate would add about \$25 a ton in four months, or by Oct. 1, so that prices paid on Oct. 1 for future delivery would be \$50 a ton higher than those now being paid on actual shipments. The total output of finished steel is about 3,000,000 net tons a month, and \$50 a ton added would make \$150,000,000 per month additional to be paid, approximately the amount Congress sought to raise with war taxes upon the whole people, and regarded in many quarters as a heavy burden. Obviously the people would find difficulty in paying such an amount to the steel industry. Of course, long term contracts, exports, and sales to the Government would have to be counted out, but still the comparison affords food for thought.

High prices for steel, high labor costs and labor scarcity, together with various war uncertainties, made it that much less than the usual proportion of steel is going into permanent structures, representing investments. Correspondingly more is going to support the common every-day activities of the people, with plenty of money to spend. The big people, the quick thinkers, readily acquired a view of what our entrance into the war meant industrially and economically. The rank and file of the people are not yet awake, but as knowledge comes to them their expenditures involving directly or indirectly the consumption of steel are likely to decrease, and since the war started they have been the chief consumers. All exports have involved not more than 25 per cent of the production, at the outside. The prospective buying of the European Allies will serve largely to replace contracts that have lately been ex-

piring, and in the next twelve-month the total movement abroad may be heavy without its exceeding 25 per cent of our capacity. The requirements of our Government appear large, but with 3,000,000 net tons a month capacity the percentage is necessarily low.

The scarcity of steel is quite pronounced, but the steel for which customers are begging the mills is steel for which engagements, down to the ultimate consumer in many instances, were entered into long ago. Steel is certain to be scarce for months, by reason of the existing pressure for it all along the line, but with the country actively engaged in war the pressure from the ordinary ultimate consumer can hardly continue indefinitely, particularly at such high prices. With price recessions at intervals the demand might be stimulated.

STEEL FOR GOVERNMENT

The 1917 naval program of the Government, for which steel was arranged about two months ago, involved a trifle more than 400,000 tons, in ship plates, structural shapes, bars and structural work for navy yard extensions. In miscellaneous orders since placed perhaps 200,000 tons more of steel has been taken up. A large tonnage of sheets, possibly running into six figures, is being arranged. The Shipping Board's program for the building of small steel freighters, in addition to the much advertised wooden freighters, is thought to involve about 40,000 tons of plates per month. The present plate rolling capacity, for plates of the thickness and width required, is estimated at about 125,000 tons a month, with perhaps 75,000 tons a month in prospect, at an average date six or eight months hence, as mills under construction are completed. Apparently nothing has been done as to shells or shell steel, and this may run into a considerable tonnage.

PIG IRON AND STEEL

While the prospects seem to be that spectacular advances in finished steel prices have come to an end, there are various realignments that may occur. Up to date billets per gross ton and finished steel products per net ton, have advanced by about the same amount, say \$60 to \$75 a ton, depending largely upon what deliveries one selects for comparison, while pig iron has advanced much less. In other words, there has been sufficient finishing capacity for all the semi-finished steel that could be produced, and plenty of pig iron for all the steel works. Of late the alignment has been changing, through steel making capacity increasing more rapidly than blast furnace capacity, while stocks of pig iron were used up some months ago. The present trend is for pig iron rather than steel to be the scarcer article, particularly as the current outcome of scrap is especially small in proportion to the output of steel. At the low point pig iron was \$13 to \$14 a ton against billets at \$19 to \$20. Now pig iron is \$42 to \$45 with billets \$90 to \$95, and pig iron may come much closer to billets. If demand continues, as it certainly will for many months, the steel mill will if necessary pay for pig iron the billet price less the cost of conversion rather than reduce the steel output.

Non-Ferrous Metal Market

Wednesday, May 23.—There is little change in prices of any of the common metals, except lead, which was advanced \$10 per ton on May 17. The tin market is strong, and the situation in spelter has improved. In the case of copper there seems to be a disposition to wait for Government developments as to price.

Tin.—Tin has advanced considerably, and Straits is now quoted at 65 to 66 cents. Some consumers are

carrying large stocks owing to the British regulations preventing them from reselling. This situation should be remedied, as some consumers cannot now use tin which they bought for cans. It is believed that the 10 per cent duty will be applied to tin. The foreign market is also strong, and has advanced considerably.

Spelter.—It is reported that the Government paid 11.50 cents for high grade, 11 cents for intermediate, and 9 cents for prime Western, for 10,000 tons. The demand for spelter is still at a very low level and ore prices remain high. Sellers are not offering large quantities, however, and this tends to keep the market fairly firm. Prompt spelter is held at 9.50 to 9.75 cents.

Copper.—The copper market has been very dull, with buying at a low ebb. Every one seems to be waiting until the Government price is settled. In the meantime, electrolytic and lake are both quoted at 32 to 32.50 cents for prompt shipment.

Lead.—The scarcity of lead still continues, and on May 17 the trust price was advanced \$10 per ton to 10 cents. The Government price had not been decided on at the time of writing.

Other Metals.—Antimony is practically unchanged at 25 cents for Chinese and Japanese. Aluminium is unchanged at 59 to 61 cents. Magnesium, unchanged, \$2.50 to \$3.00. Quicksilver, \$102.50 per flask. Pure platinum, \$105. Palladium advancing, and now \$105. Silver, 74½¢. Tungsten ore, \$17 to \$17.50 per unit.

Chemical Market

COAL TAR PRODUCTS.—There has been a light movement in all coal-tars during the fortnight, and prices have as a rule remained practically unchanged; there have been a few items that were subject to slight upward turns, however, and a few of the intermediates because of the light consuming demand were reduced under selling competition. The possibility of a 10 per cent duty on all imported goods that have been on the free list and a 10 per cent advance on dutiable merchandise has had a somewhat disconcerting effect on the market, as holders of imported goods have in some cases been induced to hold off from purchasing, and buyers who would otherwise have held their orders back have seen fit to cover in part for future requirements.

Benzol.—Due to the fact that producers have been expecting government business they have been conserving supplies by restricting their outside business to regular customers only; it is now apparent, however, that no large purchases of picric will be made for government account, and as some leading producers now have accumulations, car-lot business is not so tight as previously, and producers are making some concessions for immediate business.

Aniline Oil and Salts.—There has been a fairly steady tone to the market, and some makers are holding their prices up; there have, however, been a few lots offered on this market at comparatively low price, and these have had a rather depressing effect on the situation; much of the low-priced goods, however, have been picked up and the market is assuming a firmer tone. There has been good inquiry for the salts, and sellers are holding firmly at slightly increased prices; while a few manufacturers of the oil who had been forced out on account of the low prices have again resumed operations, the output of the salts has not increased materially.

Para Nitraniline.—There is a fair demand in evidence, although a slight overproduction is responsible for the slightly easier feeling; prices have in consequence been slightly lower. There are but a couple of makers of the *Meta Nitraniline*, and demand at this time is fairly active.

Toluol.—The offerings are still restricted, and makers are having difficulty in taking care of regular consuming demand; added to the steady absorption of the product is the fact that further orders of T. N. T. are expected to be placed by the government, although purchases for the immediate future will be light. The order recently placed for 850 tons was divided between the DuPont Co., Sement Solvay Co., and the Nitro Powder Co. One of these makers has been forced to buy toluol in the open market to fill part of their requirements. The prices at which the business was taken are low, and it is evident that explosives makers are willing to co-operate with the government in this important matter.

Ortho and Para Toluidine.—The latter particularly has been subject to strong demand, although the fact that production has increased has prevented prices from advancing further. New makers in moderate quantities are securing better yield of the *para* in proportion to the yield of *ortho*. The latter product, however, is being offered in some directions at slightly lower prices.

Phenol.—The situation is not particularly strong, due to the fact that while production has gone on steadily there has not been an important demand, and supplies have in some cases accumulated; occasional export orders, however, have helped the situation, however, and one order for 100 tons for the Orient is now in the market. Very little further progress has been made in the manufacture of phenol derivatives, and such products as *para nitro phenol*, *diphenylamine*, *meta phenylamine diamine* have been in good demand, while production is limited, and confined to a few manufacturing centers.

Naphthaline.—The flakes have been subject to somewhat wider demand, and some makers of the prime white flakes are sold up on contract, prices however have moved within narrow margins; several lots of English flakes are held in bond, which because of the 15 per cent ad valorem and 2c. per lb. specific duty, have been offered for export only; the prices in bond are somewhat below the prices quoted for domestic goods.

Nitro Naphthaline.—Demand is very limited, and makers have been induced to make concessions for firm business; *dinitro naphthaline* is not offered with so much freedom, as makers are using the product in the manufacture of *alpha naphthylamine*. There is fair export and domestic demand for this latter product, although the entrance of new makers into the field has caused a reduction of prices.

Naphthylamine Di Sulphonic Acid.—(1:3:6 Acid)—This product is now being made on a moderate scale by large manufacturers, who expect to develop a fairly wide field for it.

Xylol.—There is a fair demand for this product, although the commercial and some of the higher grades are offered by large makers at slightly lower figures. The *Solvent Naphthas* are rather weak, as demand is not particularly strong, and important accumulations are held by big factors. Manufacturers are endeavoring to widen the scope of the use of the light naphthas by using as a substitute for turpentine.

Salicylates.—The demand for the manufacture of *Acetyl Salicylic* and for medicinal use has caused an exceedingly strong market, as supplies are near the vanishing point; the new makers are endeavoring to their utmost to supply immediate requirements.

HEAVY CHEMICALS

The market has been quiet, with the exception of a half dozen or more of the items that come under this classification. The falling off in export business has been the chief reason for this, and shipments to Europe are particularly light at this time; the South American

trade however has progressed in a moderately satisfactory manner.

Soda Ash.—The market has been rather weak, as export shipments have been light, and consuming demand has not materially widened. The tightness of the cooerage situation has induced manufacturers to put up ash in bags to a greater extent than previously, with the result that prices in bags have lessened, and the differential between prices in barrels and bags is greater than ever before in the history of the industry.

Caustic Soda.—A heavy speculative demand has forced prices up, and spot or nearby deliveries are now held at considerably over 6c.; contract business for the balance of the year, and over 1918 is progressing steadily, at higher levels.

Bleaching Powder.—Prices have slumped rapidly during the last two weeks, and both domestic drums and goods packed in export containers offered freely at lower prices; a purely buyer's market prevails, and on real business the purchaser could almost establish his own price.

Bichromates of Soda.—This highly manipulated market has been rather quiet lately, and concessions are made for export business. Makers are endeavoring to hold up the price for domestic consumption, and in some cases makers have been buying back their supplies in small lots. The *potash* has held steadily at prices that have not varied much.

Cyanides.—The markets on *soda* and *chloride mixture* have weakened considerably, due to the presence of English goods in the market, the absence of heavy demand, and the fact that domestic manufacturers are getting ready for placing on the market the output of their new plant.

Formaldehyde.—Heavy demand, and the absence of spot supplies on the market, has caused considerable strength, and advances have been more or less rapid.

Arsenic.—Makers are sold far ahead, on carlot business, and the limited offerings for nearby delivery are held at high prices. Demand is heavy from Paris green makers.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET MAY 22, 1917

Acetic anhydride	lb.	1.50	1.75
Acetone, drums	lb.	.27	.27½
Acid, acetic, 28 per cent.	lb.	.05	.05½
Acetic, 56 per cent.	lb.	.09½	.10
Acetic, glacial, 99½ per cent, carboys.	lb.	.29	.30
Boric, crystals	lb.	.11	.11½
Citric, crystals	lb.	.73½	.75
Hydrochloric, commercial, 18 deg.	lb.	.01½	.01½
Hydrochloric, 20 deg.	lb.	.01½	.01½
Hydrochloric, C. P. conc., 22 deg.	lb.	.01½	.01½
Hydrofluoric, 30 per cent, in barrels	lb.	.04½	.05
Lactic, 44 per cent.	lb.	.11	.12
Lactic, 22 per cent.	lb.	.04½	.05
Nitric, 36 deg.	lb.	.06½	.07
Nitric, 42 deg.	lb.	.07½	.08
Oxalic, crystals	lb.	.44	.46
Phosphoric, 85 per cent.	lb.	.33	.37
Picric	lb.	.70	.75
Pyrogallol, resublimed	lb.	3.50	4.00
Sulphuric, 60 deg.	ton	20.00	22.00
Sulphuric, 66 deg.	ton	30.00	35.00
Sulphuric, oleum (Fuming), tank cars.	ton	38.00	40.00
Tannic, U. S. P., bulk	lb.	.45	.50
Tartaric, crystals	lb.	.79	.82
Alcohol, grain, 188 proof.	gal.	3.05	3.07
Alcohol, wood, 95 per cent.	gal.	1.00	1.02
Alcohol, denatured, 180 proof.	gal.	.70	.72
Alum, ammonia lump.	lb.	.04	.04½
Alum, chrome ammonium	lb.	.18½	.20
Alum, chrome potassium	lb.	.40	.45
Alum, chrome sodium	lb.	.12	.12½
Alum, potash lump.	lb.	.07	.07½
Aluminium sulphate, technical	lb.	.02	.02½
Aluminium sulphate, iron free.	lb.	.03	.03½
Ammonia aqua, 26 deg. carboys.	lb.	.06	.07
Ammonium carbonate	lb.	.14	.17
Ammonium nitrate	lb.	.16	.17
Ammonium, sulphate domestic	lb.	.05½	.06
Amyl acetate	gal.	4.00	4.25
Arsenic, white	lb.	.18	.19
Arsenic, red	lb.	.30	.60
Barium chloride	ton	85.00	90.00

Barium sulphate (Blanc Fixe, powder).....	lb.	.04	—	.04½
Barium nitrate.....	lb.	.11	—	.12½
Barium peroxide, basic 70 per cent.....	lb.	.27	—	.27½
Bleaching powder, 35 per cent chlorine.....	lb.	.03	—	.03¼
Borax, crystals, sacks.....	lb.	.08	—	.08½
Bromine, crude.....	ton	45.00	—	—
Bromine, technical.....	lb.	.80	—	.80
Calcium, acetate, crude.....	lb.	.03	—	.03½
Calcium, carbide.....	ton	80.00	—	90.00
Calcium chloride, 70-75 per cent, fused, lump.....	ton	26.00	—	28.00
Calcium peroxide.....	lb.	1.80	—	1.90
Calcium phosphate.....	lb.	.30	—	.31
Calcium sulphate.....	lb.	.01	—	.02
Carbon bisulphide.....	lb.	.04½	—	.04½
Carbon tetrachloride, drums.....	lb.	.15½	—	.16
Caustic potash, 82-92 per cent.....	lb.	.76	—	.78
Caustic soda, 76 per cent.....	100 lb.	6.15	—	6.25
Chlorine, liquid.....	lb.	.15	—	.18
Cobalt oxide.....	lb.	1.53	—	1.60
Copperas.....	100 lb.	1.05	—	1.10
Copper carbonate.....	lb.	.33	—	.35
Copper cyanide.....	lb.	.—	—	.78
Copper sulphate, 99 per cent, large crystals.....	lb.	.19½	—	.20
Cream of tartar, crystals.....	lb.	.48	—	.49
Epsom salt, bags.....	100 lb.	3.50	—	4.00
Formaldehyde, 40 per cent.....	lb.	.17	—	.18
Gaube's salt.....	100 lb.	1.02	—	.64
Glycerine, bulk, C. P.....	lb.	.38½	—	.59
Iodine, resublimed.....	lb.	3.50	—	—
Iron oxide.....	lb.	.02	—	.08
Lead, acetate, white crystals.....	lb.	.14	—	.14½
Lead arsenate.....	lb.	.10½	—	.11½
Lead nitrate.....	lb.	.16½	—	.17
Litharge, American.....	lb.	.08	—	.10
Lithium carbonate.....	lb.	1.02	—	1.05
Manganese dioxide.....	lb.	.65	—	.66
Magnesium carbonate, tech.....	lb.	.11	—	.11½
Nickel salt, single.....	lb.	.14	—	.14½
Nickel salt, double.....	lb.	.11	—	.12
Phosphorus, red.....	lb.	1.15	—	1.25
Phosphorus, yellow.....	lb.	1.20	—	1.25
Potassium bichromate.....	lb.	.34½	—	.35
Potassium bromate, granular.....	lb.	1.00	—	1.05
Potassium carbonate calcined, 80-85 per cent.....	lb.	.55	—	.65
Potassium chlorate, crystals.....	lb.	.58	—	.60
Potassium cyanide, 98-99 per cent.....	lb.	2.10	—	2.20
Potassium iodate.....	lb.	2.90	—	3.02
Potassium nitrate 80-85 p. c. basis of 80 p. c.....	ton	375.00	—	400.00
Potassium nitrate.....	lb.	.30	—	.34
Potassium permanganate.....	lb.	3.90	—	4.00
Potassium prussiate, red.....	lb.	2.60	—	2.70
Potassium prussiate, yellow.....	lb.	.95	—	1.00
Potassium sulphate, 90-95 p. c. basis 90 p. c.....	ton	330.00	—	375.00
Rochelle salts.....	lb.	.37½	—	.38½
Sal ammoniac, gray gran.....	lb.	.11	—	.12
Sal ammoniac, white gran.....	lb.	.17	—	.18
Sal soda.....	100 lb.	1.10	—	1.20
Salt cake.....	100 lb.	.90	—	1.00
Silver cyanide.....	oz.	.70	—	—
Silver nitrate.....	oz.	.46½	—	—
Soda ash, 58 per cent, light, flat.....	100 lb.	2.80	—	2.90
Soda ash, 58 per cent, dense, flat.....	100 lb.	3.35	—	3.65
Sodium acetate.....	lb.	.08½	—	.09
Sodium benzoate.....	lb.	6.00	—	6.50
Sodium bicarbonate, domestic.....	100 lb.	2.10	—	2.20
Sodium bicarbonate, English.....	lb.	.—	—	.15
Sodium bichromate.....	lb.	.14½	—	.15
Sodium bisulphate, powder.....	lb.	.03½	—	.04
Sodium chlorate.....	lb.	.23½	—	.25
Sodium cyanide.....	lb.	.80	—	.90
Sodium fluoride, commercial.....	lb.	.12	—	.12½
Sodium hyposulphite.....	lb.	.01½	—	.02
Sodium nitrate, refined.....	lb.	.05½	—	.05¾
Sodium nitrite.....	lb.	.28	—	.30
Sodium peroxide.....	lb.	.90	—	.95
Sodium phosphate (tri).....	lb.	.04½	—	.04¾
Sodium prussiate, yellow.....	lb.	.30	—	.31
Sodium silicate, liquid—40 deg. B. m.....	100 lb.	1.50	—	1.60
Sodium sulphate, 30 per cent crystals.....	lb.	.02¾	—	.03
Sodium sulphide, 60 per cent, fused.....	lb.	.03½	—	.03¾
Sodium sulphite.....	lb.	.03½	—	.03¾
Strontium nitrate.....	lb.	.28	—	.30
Sulphur chloride, drums.....	lb.	.11	—	.12
Sulphur dioxide, liquid, in cylinders.....	lb.	.12	—	.14
Sulphur, flowers, sublimed.....	100 lb.	3.20	—	3.30
Sulphur, roll.....	100 lb.	2.55	—	2.60
Sulphur, crude.....	ton	45.00	—	46.00
Tin bichloride, 50 deg.....	lb.	.19½	—	.20
Tin oxide.....	lb.	.66	—	.67
Tungstic acid, basis 100 per cent.....	lb.	1.40	—	1.50
Zinc carbonate.....	lb.	.25	—	.27
Zinc chloride.....	lb.	.16	—	.17
Zinc cyanide.....	lb.	.50	—	—
Zinc dust, 350 mesh.....	lb.	.19	—	.20
Zinc oxide, American process XX.....	lb.	.13½	—	.14
Zinc sulphate.....	lb.	.03½	—	.06

Coal Tar Products (Crude)

Benzol, pure, water white.....	gal.	.56	—	.60
Benzol, 90 per cent.....	gal.	.57	—	.59
Toluol, pure, water white.....	gal.	1.85	—	2.00
Xylol, pure, water white.....	gal.	.55	—	.65
Solvent naphtha, white.....	gal.	.18	—	.20
Solvent naphtha, crude, heavy.....	gal.	.13	—	.16
Cresote oil, 25 per cent.....	gal.	.30	—	.32
Piteb, various grades.....	ton	8.00	—	20.00
Carbolic acid, crude, 95-97 per cent.....	lb.	1.00	—	1.05
Carbolic acid, crude, 50 per cent.....	lb.	.75	—	.80
Carbolic acid, crude, 25 per cent.....	lb.	.30	—	.32
Cresol U. S. P.....	lb.	.20	—	—

Intermediates, Etc.

Alpha naphthylamine.....	lb.	.90	—	1.05
Aniline oil.....	lb.	.20	—	.31
Aniline salts.....	lb.	.34	—	.35
Anthracene, 80 per cent.....	lb.	.10	—	—
Benzaldehyde.....	lb.	4.50	—	5.00

Benzidine, base.....	lb.	1.85	—	1.90
Benzidine, sulphate.....	lb.	.23	—	1.65
Benzoic acid.....	lb.	6.00	—	6.50
Beta naphthol, sublimed.....	lb.	.80	—	.85
Beta naphthylamine com.....	lb.	2.50	—	—
Bisphenol A.....	lb.	.24	—	.24
Dinitrochlorobenzol.....	lb.	.46	—	.48
Dimethylamine.....	lb.	.58	—	.59
Diphenylamine.....	lb.	.95	—	1.00
Diethylamine.....	lb.	.95	—	Nominal
Metaphenylenediamine.....	lb.	1.60	—	1.65
Monochlorobenzol.....	lb.	.30	—	.32
Naphthalene, flake.....	lb.	.10	—	.10½
Naphthionic acid, crude.....	lb.	1.50	—	1.75
Nitro naphthaline.....	lb.	.45	—	.50
Ortho-amidophenol.....	lb.	—	—	—
Ortho-toluidine.....	lb.	1.00	—	1.15
Para-amidophenol, base.....	lb.	5.00	—	5.50
Parantraniline.....	lb.	1.15	—	1.25
Paraphenylenediamine.....	lb.	3.56	—	3.75
Phenol, U. S. P.....	lb.	1.90	—	2.00
Resorcin, technical.....	lb.	.42	—	.44
Resorcin, pure.....	lb.	16.00	—	17.00
Salicylic acid.....	lb.	1.15	—	1.20
Salol.....	lb.	.70	—	.75
Sulphanilic acid.....	lb.	.33	—	.35
Toluidin.....	lb.	3.00	—	—
Toluidine-mixture.....	lb.	.75	—	.80

Petroleum Oils

Crude (at the Wells)

Pennsylvania.....	bbl.	3.10	—	—
Corning, Ohio.....	bbl.	.60	—	—
Somerset, Ky.....	bbl.	2.20	—	—
Wootter, Ohio.....	bbl.	2.18	—	—
Indiana.....	bbl.	1.78	—	—
Illinois.....	bbl.	1.92	—	—
Oklahoma and Kansas.....	bbl.	1.70	—	—
Caddo, La., light.....	bbl.	1.90	—	—
Corsicana, Tex., light.....	bbl.	1.70	—	—
California.....	bbl.	.78	—	.87
Gulf Coast.....	bbl.	1.00	—	—

Lubricants

Black, reduced, 29 gravity, 25-30 cold test.....	gal.	.13½	—	.14
Cylinder, light.....	gal.	.21	—	.26
Cylinder, dark.....	gal.	.18	—	.19
Paraffine, high viscosity.....	gal.	.21½	—	.30
Paraffine, 903 sp. gr.....	gal.	.21½	—	.22
Paraffine, 865 sp. gr.....	gal.	.18½	—	.19

Flotation Oils

(Prices at New York)

Pine oil, steam distilled, sp. gr. 0.925-0.940.....	gal.	.52	—	—
Pine oil, destructively distilled, sp. gr. 0.920-0.940.....	gal.	.48	—	—
Pine-tar oil, sp. gr. 1.025-1.035.....	gal.	.25½	—	—
Pine-tar oil, double refined, sp. gr. 0.965-0.990.....	gal.	.35	—	—
Pine oil, light, sp. gr. 0.950, tank cars, f.o.b. works.....	gal.	.37	—	—
Pine oil, heavy, sp. gr. 1.025, tank cars, f.o.b. works.....	gal.	.26	—	—
Pine tar, thin, sp. gr. 1.060-1.080.....	gal.	.22	—	—
Turpentine, crude, sp. gr. 0.980-1.000.....	gal.	.40	—	—
Hardwood oil, f.o.b. Michigan, sp. gr. 0.960-0.990.....	gal.	.19	—	—
Hardwood oil, f.o.b. Michigan, sp. gr. 1.06-1.08.....	gal.	.19	—	—

Vegetable and Other Oils

China wood oil.....	lb.	.16	—	.16½
Cottonseed oil, crude.....	gal.	1.11	—	—
Linseed oil, raw, cars.....	gal.	1.22	—	—
Peanut oil, crude.....	gal.	1.15	—	—
Rosin oil, first run.....	gal.	.38	—	—
Rosin oil, fourth run.....	gal.	.67	—	—
Soya bean oil, Manchuria.....	lb.	.14½	—	—
Turpentine, spirits.....	gal.	.49	—	—

Miscellaneous Materials

Barytes, floated, white, foreign.....	ton	38.00	—	40.00
Barytes, floated, white, domestic.....	ton	28.00	—	32.00
Beswax, white, pure.....	lb.	.55	—	.60
Carbunax, wax, flur.....	lb.	.19	—	.28
Cassein.....	lb.	.19	—	.28
Chalk, light, precipitated, English.....	lb.	.03	—	.06
Feldspar.....	ton	8.00	—	12.00
Fuller's earth, powdered.....	100 lb.	.80	—	1.05
Ozokerite, crude, per lb. of Mo.....	lb.	.60	—	.70
Ozokerite, American.....	lb.	.35	—	—
Red lead, dry, carloads.....	lb.	.12	—	—
Rosin, 280 lb.....	bbl.	6.35	—	—
Sonstone.....	ton	10.00	—	12.50
Tale, American, white.....	ton	10.00	—	13.00
White lead, dry.....	lb.	.10½	—	—

Refractories, Etc.

(F.O.B. Works)

Chrome brick.....	net ton	Nominal	—	—
Chrome cement, Grecian.....	net ton	69.00	—	—
Clay brick 1st quality.....	per 1000	45.00	—	—
Clay brick, second quality.....	per 1000	30.00	—	—
Magnesite, raw.....	ton	30.00	—	35.00
Magnesite, calcined.....	ton	40.00	—	55.00
Magnesite, Grecian, del. burned.....	net ton	90.00	—	—
Magnesia brick, Grecian, 9x4½x2½.....	net ton	140.00	—	—
Silica brick.....	per 1000	45.00	—	—

Ferroalloys

Ferrochromium.....	lb.	Nominal	—	—
Ferromanganese, domestic, delivered.....	ton	400.00	—	425.00
Ferromanganese, English.....	ton	200.00	—	—
Ferromolybdenum, per lb. of Mo.....	lb.	4.00	—	—
Ferrosilicon, 50 per cent, carloads, del. Pittsburgh.....	ton	240.00	—	250.00
Ferrosilicon, 50 per cent, contract.....	ton	100.00	—	—
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh.....	lb.	2.00	—	—
Ferrovanadium, f.o.b. works.....	lb.	3.25	—	3.50

Delaware

WILMINGTON.—The Wilmington Steel Company, a subsidiary of the Midvale Steel Company, is opening a new rolling mill with five open-hearth furnaces of 50 tons capacity. It is said that the Midvale interests are preparing to develop Cuban ore properties which will be brought to the Wilmington plant. The Wilmington company is operating the plant which once belonged to the Diamond State Steel Company and which had lain idle for fourteen years.

Georgia

SAVANNAH.—The Savannah Sugar Refining Corporation will build a large barrel factory at its plant at Fort Wentworth. The factory will turn out about 2700 barrels a day. The large refining buildings are practically complete, but there is considerable work to be done before the filters and other apparatus are in perfect order. The company will manufacture white sugar.

Idaho

KAMIAH.—Kamiah Asbestos Manufacturing Company, here, has a tentative order from Japanese interests to purchase 1800 tons of asbestos fiber at a price of \$45,000. The Japanese merchants first wish a sample shipment of 10 tons. The company owns huge deposits of asbestos near Kamiah, where it has a small plant. Plant is manufacturing calcimine from asbestos and other ingredients.

KELLOGG.—The Washington Water Power Company has completed erection of its new substation in this city, from which it will supply current to operate the smelter of the Bunker Hill & Sullivan Mining and Concentrating Company, now nearing completion. About 4000 hp. will be required for the operation of the smelter and 3000 hp. for the mill.

LEADORE.—The Sunset Mining Company, here, plans installation of a mill, which will have capacity of 200 tons daily. Company owns large silver and lead properties near this city.

LEONIA.—Directors of the Idaho Copper Mining Company recently voted to increase the capital stock of the company from \$1,000,000 to \$2,000,000, to finance further development and to change the company name to Idaho Lead & Copper Company. E. J. Merrin, president.

STILES.—More than \$150,000 will be spent in the vicinity of Stiles by C. E. Sample of Golden, and associates, by installation of stamp mills at the properties of the Golden Mining & Milling Company and at the New York mine.

Illinois

MOLINE.—The Republic Iron & Steel mills is erecting a large addition, costing \$28,000. A two-story office will also be erected.

ROCK ISLAND.—The new paint factory of the Illinois Oil Company will be enlarged at a cost of \$35,000.

Indiana

HUNTINGTON.—The Huntington Steel Foundry Company will build a two-story addition to its plant, 40 by 50 ft.

RICHMOND.—The Swayne Robinson Company is building a large addition to its factory. The building will be 180 ft. long by 60 ft. wide and one story, and will be used as a foundry. It will be finished by July 1.

Kansas

WICHITA.—The Augusta Petroleum & Refining Company has purchased a ten-acre tract of land on which it will build a 3000 barrel oil refinery. The company is capitalized at \$250,000 and owns leases in the Butler County oil fields.

Maine

ORONO.—The Orono Pulp & Paper Company is making extensive improvements at its plant.

Maryland

BALTIMORE.—The Baltimore Tube Company is reported to be planning for the enlargement of its plant on East Baltimore Street for the rolling of sheet copper tubing.

Massachusetts

NEW BEDFORD.—The Taunton-New Bedford Copper Company is building an addition to its plant which will cost about \$400,000. The addition will include a rolling mill and an engine shop. They will be equipped with the most modern machinery.

Mexico

MEXICO CITY.—Metal foundries, smelters and metallurgical plants have been instructed by the department of fomento to resume operations before May 28, as conditions, it is asserted, are now such that the raw materials from the mines are available.

Michigan

PETOSKY.—The paper mill here will construct an addition to its bleach manufacturing plant. When it is completed the plant will be able to manufacture all the bleach necessary to take care of the increase in pulp production and make the entire output of the mill bleached pulp.

New Jersey

ATLANTIC CITY.—The old paper mill at Pleasant Mills will shortly be put into operation in charge of Alexander McKeone. Paper will be made from salted hay.

CHROME.—E. C. Klipstein & Company has awarded a contract to the William L. C. Construction Company, 103 Park Avenue, New York, for the erection of five buildings at South Charleston, W. Va., for its proposed new chemical plant. Other buildings have been awarded to Almirall & Company, 1 Dominick Street, New York, for three other structures.

ELIZABETH.—The Bayway Chemical Company will erect a subsidiary building at Bayway plant.

IRVINGTON (Newark).—The Jackson Chemical Works, recently incorporated, has filed plans for the erection of a one-story addition to its plant at 487 Chancellor Avenue. Harry DeG. King and John E. Jackson are heads of the company.

JERSEY CITY.—The Seydel Manufacturing Company, 38 Fort Street, manufacturers of chemicals, will build a 2-story addition to its plant to cost about \$34,000.

JERSEY CITY.—Fire recently destroyed a portion of the plant of the Syn Chemical Manufacturing Company, Culver Avenue, with loss estimated at about \$10,000.

JERSEY CITY.—The Interstate Chemical Company, 673 Garfield Avenue, has filed plans for the erection of a 1-story addition.

NEWARK.—The American Oil Export Company is planning for extensions to its oil refining plant at Port Newark Terminal. The company has recently acquired about 6 acres of property for this purpose.

NEWARK.—George H. Segal Company, 95 William Street, New York City, has leased property on Meadow Street. Kearny meadow section, consisting of a 2-story factory building and will establish new chemical manufacturing plant.

NEWARK.—O. W. Young's Oils, Inc., has acquired property at 33 Ross Street, and will establish an oil refining plant to specialize in the production of greases, lubricants.

NEWARK.—The Elizabethtown Smelting Company has filed plans for the erection of a 1-story addition to its plant at 511 Mulberry Street.

PAULSBORO.—The Mantua Chemical Company will soon commence the erection of a 1-story crusher plant, about 10 x 40 ft. and 10 x 65 ft. Harrison Brothers & Company, Inc., Thirty-fifth Street, Philadelphia, Pa., operate this company.

SALEM.—The Salem Brass & Iron Foundry Company is planning for the early operation of the former plant of the Hess Steel Company as an addition to its works. The plant has been reconstructed and machinery and equipment are now being installed.

New York

BUFFALO.—The Schoellkopf Aniline & Chemical Co. is planning to build an extension which will cost \$135,000. The concern intends to put up an ice plant which will cost \$65,000, a factory and machine shop to cost \$70,000. The company has spent millions of dollars during the last two years in building.

FAYETTEVILLE.—McIntyre Brothers & Rondebush, Inc., manufacturers of paper, are taking bids for the erection of an addition to their plant, about 80 x 135 ft. The company will also build a new reinforced concrete spillway for water power for plant operation.

NEW YORK CITY.—The Sinclair Gulf Corporation has obtained a concession from the Republic of Panama to exploit about ten million acres for petroleum. The property involved is on both coasts. The work is under the direction of Mr. D. T. MacDonald.

SYRACUSE.—The McIntyre Brothers & Rondebush, Inc., are planning to build a large mill at Fayetteville. The new buildings and equipment will more than triple the output of the plant.

Ohio

COLUMBUS.—The Carbo-Hydrogen Company of America with head office at Pittsburgh has purchased an acre and a half of ground from the Rood Box Company and will erect a factory building.

YOUNGSTOWN.—Extensions costing about \$4,000,000 are being planned by the Brier Hill Steel Co. and the Trumbull Steel Co. Both companies will erect large plants.

Oklahoma

BRISTOW.—The Concord Oil Company, capitalized at \$7,000,000, will erect a refinery here. The plant will manufacture all of the products and by-products of oil.

Oregon

RILEY.—J. H. Morton and L. M. Dunn, here, will organize a company to exploit 3800 acres of rich nitrate rock on the border between Lake and Harney counties, near Bend, Ore.

Pennsylvania

ALLENTOWN.—The National Slag Company is planning for the installation of a new 600-ton open hearth with necessary operating equipment. The production of this plant is being used by the Bethlehem Steel Company at its Cornwall blast furnaces.

BELLWOOD.—The Bellwood Foundry & Machine Company has filed articles of incorporation with a capital of \$20,000 to operate a local iron and steel casting works. The former Trenton Bellwood Manufacturing Company has been acquired for initial operations. It is reported that extensions are considered. George C. Bland, Tipton, is head of the company.

BRIDGEPORT.—The plant of Joseph H. Roach & Company, manufacturers of all-steel water tube boilers, has been purchased by the Badenhauser Company, Philadelphia. Increased output is contemplated.

HARRISBURG.—The former plant of the Lochiel Steel Company has been acquired by the American Manganese Manufacturing Company (Edward E. Marshall, president), Bullitt Building, Philadelphia. Extensive improvements and extensions are now being made to effect an initial capacity of about 125 tons of pig iron and 12 tons of ferro-manganese per day. This plant has recently been in the possession of the Bethlehem Steel Company.

HARRISBURG.—The Harrisburg Welding, Brazing & Machine Works, 947 Cameron Street, has completed the erection of a 2-story addition to be used for brazing and welding work. A. A. Hayward and J. C. Garverick are heads of the company.

KITTANNING.—The Kittanning Iron & Steel Manufacturing Company is now controlled by Charles McKnight of Pittsburgh, banker and manufacturer. It is said that \$1,000,000 was involved in the transfer.

MARIETTA.—The National Casting Company has acquired the former plant occupied by the Nacette Manufacturing Company, and will use the structure for extensions.

NEWTOWN.—The Newtown Porcelain Works has been organized by officials of the Imperial Porcelain Company, Trenton, N. J., to take over the plant of the Newtown China Company, and operate the works for the manufacture of electric porcelain goods. The plant, as a branch of the main plant at Trenton. The Imperial company is also arranging for the erection of a new plant at Neptune City, N. J., with initial operations to employ about 200 people. Frederick A. Dugan and B. B. Dinsmore are heads of the company.

PENNSBURG.—Fire, May 13, destroyed the paper mill of the Perkiomen Paper Company, with loss estimated at \$4,000. Charles G. Hillegas is head of the company.

PHILADELPHIA.—The General Manufacturing Company, Swanson Street and Snyder Avenue, has filed plans for the erection of a 1-story addition to its plant.

PHILADELPHIA.—Powers-Weightman-Rosenkaten Company, manufacturers of sulphuric, nitric and mixed acids, will build a 1-story addition to its plant at 800 North Hutchinson Street, about 40 x 50 ft., to cost \$14,000.

PITTSBURGH.—The Pennsylvania Railroad Company will build a 1-story addition to its brass working plant on Pennsylvania Avenue to cost about \$10,000.

POTTSTOWN.—The Nagle Steel Company will inaugurate operations at the former plant of the Potts Brothers Iron Company, recently acquired. The plate mill and other departments of the plant have been remodeled and improved and will soon be operated at full capacity. The company is also arranging for improvement work at its Rahway, N. J., plant.

READING.—The Reading Steel Casting Company is having plans prepared for a new 1-story steel frame addition, about 40 x 60 ft. William H. Dechart & Son, Bacr Building, are the architects.

SCRANTON.—The Maccar Truck Company is arranging for the immediate erection of a 1-story reinforced-concrete and steel addition about 75 x 300 ft., to cost approximately \$100,000. It is also planned to build a new power house in connection.

WILKES-BARRE.—The Pressed Steel Company, North Pennsylvania Avenue, specializing in the manufacture of steel plates, sheet piling, etc., will build a 1-story addition, about 57 x 80 ft.

Tennessee

LEWISBURG.—The Lewisburg Foundry Company will enlarge its plant, thereby almost doubling its capacity.

NASHVILLE.—The Hart Manufacturing Company of Grand Rapids, Mich., will build a plant in Knoxville, where it will manufacture brass articles. Knoxville was selected owing to its proximity to the copper and zinc fields.

Texas

HOUSTON.—The Texas Chemical Company will build a brick and steel chemical plant, which will cost \$51,000. It will be the first and largest of plants on the channel. Fertilizer and various by-products, which include ammonia and greases and bone charcoal for sugar refining will be the regular products. The Texas Chemical Company is affiliated with Stauffer interests of California.

Utah

SALT LAKE CITY.—The Lakeview Mining Company has been taken over by a syndicate of New York capitalists. The property consists of lead and zinc deposits carrying considerable silver.

Virginia

NEWPORT NEWS.—In connection with proposed plant extensions at the Newport News Shipbuilding & Dry Dock Company's plant a foundry addition is planned for the production of steel castings. H. L. Ferguson is president.

Washington

SEATTLE.—The Pacific Oil Mills of Seattle will expend \$25,000 in enlarged plant and facilities at Seattle. Arrangements have been completed whereby the company will lease a 16-acre tract in the Dawlish Wayward from King County. The county will also construct a dock in front of the tract which the company will rent.

SEATTLE.—The Superior Steel Corporation, originally organized with \$750,000, is planning to manufacture steel here from ore mined in British Columbia. The incorporators are G. L. Casey, T. H. Piddick and E. W. French of Seattle. Mr. Casey is head of the company, and has been located here for about ten years.

SEATTLE.—The city of Seattle has given permission to the Sound Paper Company to complete the development of the largest pulp mill in the Pacific States, which it contemplates building. Mr. H. O. Pond is president of the company. The company was incorporated several months ago with a capital of \$3,000,000 and it is estimated that \$10,000,000 will be required to build the plant and as much more for the full development of the Sultan water power project. The Seattle Power Development Company had plans for the development of this water power for use by the city, but the city decided it was not needed, and the power company was free to go ahead and obtain Government permission.

SEATTLE.—The West Coast Chemical Company is now planning to acquire from 25 to 50 acres on which it proposes to erect a plant for the manufacture of coal tar products.

SPOKANE.—The Loon Lake Copper Company, here, plans construction of a mill at its properties, to cost between \$30,000 and \$40,000, and to have capacity of 150 tons daily. Frank G. Crane, secretary-treasurer.

SPOKANE.—R. S. Talbot, here, who is developing several hundred acres of magnesite in the Chewelah district, states a second railroad will build during the summer. The products are used in steel manufacture.

TACOMA.—It is announced that large supplies of high grade chrome ore will be shipped from a deposit on Cypress island, near Anacortes, to the Bilroze Alloys Company's smelter in Tacoma for manufacture into ferrochrome. W. F. Rowe, president of the company, after investigating the deposit, has arranged to take all the ore mined.

West Virginia

WEST CHARLESTON.—The Rollin Chemical Company will double its present factory space and equipment at a cost of about \$5,000. Five new buildings will be constructed and equipped and are expected to be finished by January 1 of next year.

WHEELING.—The first unit of the United Zinc Corporation is practically completed. The first unit will employ about 1000 men. The work of building the remainder of the plant will be started and rushed to completion.

Wisconsin

NEENAH.—The John Strange Paper Company is building a new mill adjacent to the present plant. The capital has increased from \$150,000 to \$500,000.

Canada

PRINCETON, B. C.—The British Columbia Copper Company is formulating plans for equipping its mill to produce 2000 tons daily, and installation of a power plant and mill to handle this tonnage.

TRAIL, B. C.—The Consolidated Mining & Smelting Company has announced that the smelter will be producing 2000 tons daily, and installation of a power plant and mill to handle this tonnage. For silver-lead ore, the company will settle on the average quotations of the London market, succeeding in the upon which its coke stock is replenished, and an adequate supply of coke is assured. Advances will be made against shipments if desired as soon as the analyses are available after arrival, on the usual basis of 90 per cent of an estimated value, calculated upon quotations of the date of arrival. Interest on the advances will be charged at 7 per cent until the date upon the coke is replenished, and regular supplies assured, or the company will make the usual 90 per cent estimated advance upon that date.

GREENWOOD, B. C.—Coke shortage is closing down the Greenwood and Grand Forks smelters and throwing hundreds of men out of employment. Northport is also affected. The present is the first time since the Consolidated Company owned and operated the Trail smelter that the copper furnaces have all been cold at one time. Lack of coke is also said to be playing havoc with the interior smelters.

Manufacturers' Notes

W. A. BUTCHART of Denver, Col., has recently started a new plant of enlarged capacity for the manufacture of concentrating tables and other apparatus at 1320 Eleventh Street, Denver.

THE DRAEGER OXYGEN APPARATUS COMPANY has moved its plant from 413 First Ave., Pittsburgh, Pa., to 807 Hay Street, Wilkinsburg Station, Pittsburgh, Pa.

THE SMITH GAS ENGINEERING COMPANY of Lexington, Ohio, has furnished the Ball Brothers Manufacturing Company of Muncie, Ind., two four-section units for the production of their glass pots; the Standard Aniline Products, Inc., Wap-pingers Falls, New York, a second gas producer unit, which will be used in heating their chemical apparatus; used by this company; Chas. Goldt Company, Cincinnati, Ohio, two three-section gas producer units for use in glass manufacture; and the Dayton Engineering Laboratories Company of Dayton, Ohio, two gas producers for use in its heat treating department.

THE SHARPLES SPECIALTY COMPANY, centrifugal engineers of West Chester, Pa., has opened a New York office at 110 Astor Trust Building, Forty-second Street and Fifth Avenue, in charge of Nax B. Miller. Mr. Miller will look after New York and New England territory.

ARTIFICIAL ABRASIVES.—In our issue of May 1 it was stated that the National Abrasive Company of Boston, Mass., were manufacturers of carbolon. This is a mistake, as carbolon is made by the Exolon Company, of Cambridge, Mass. The National Abrasive Company will make its artificial corundum under the name of "Nattite."

UNITED FILTERS, INC.—The Kelly Filter Press Company, the Sweetland Filter Press Company, and the American Filter Company have consolidated into a company to be known as the United Filters, Inc. The company is sole owner of all patents covering the Kelly filters, the Sweetland filters, and the American continuous suction filters. The home office is at the Felt Building, Salt Lake City, and the eastern office at 36 Flatbush Avenue Extension, Brooklyn, N. Y.

TUBE MILL LINING.—The Jasper Quarry Company of Sioux City, Iowa, has placed on the market an adamic silica tube mill lining. It has been used successfully in cyanide plants and cement mills and also in a silica plant in Oregon, Ill. The analysis of the material is as follows: silica, 94.0 per cent; silicate of alumina and potash (orthoclase), 2.4 per cent; hydrous silicate of lime, iron and alumina (enidote), 2.0 per cent; oxide of iron (hematite), 1.6 per cent.

MARDEN, ORTH & HASTINGS COMPANY OPENS NEW BRANCH.—For the better service of its customers in the Far West, Marden, Orth & Hastings Company has just opened a new branch office in the Hoge Building, Seattle. Its Seattle office is the fifth American branch of this firm, which has its main office at 61 Broadway, New York. Besides New York and Seattle, it has branches at 225 Purchase Street, Boston; 130 North Fifth Avenue, Chicago; 316 Clay Street, San Francisco; and Rockefeller Building, New York. The company handles heavy chemicals, coal-tar intermediates, aniline dyes, dyewood extracts, tanning extracts, oils and greases. It has six factories in America, and a large staff of representatives in all the leading countries of the world, and long-established direct connections with foreign firms for the import of goods not producible in the United States.

HERMAN A. HOLZ, dealer in precision and testing instruments and pyrometers, has moved from 50 Church Street, New York, to larger quarters in the Metropolitan Tower at J. M. Macfarlane Building.

THE INDUSTRIAL SERVICE & EQUIPMENT COMPANY announces that after May 1, 1917, its offices will be located at 226 Devonshire Street, Boston, Mass.

THE LINK-BELT COMPANY announces that it has printed in colors a portion of President Wilson's proclamation, which is of particular interest to manufacturers at the present time. The company will be glad to send a copy to anyone writing to the Chicago plant.

TRINITROTOLUOL TAX.—The Board of United States General Appraisers recently rendered a decision sustaining the contention of the Giant Powder Company (Inc.) T. N. T. should come in duty free. In a previous decision it was classified as a coal tar preparation and therefore dutiable.

MARCY MILL HAS NEW HEADQUARTERS.—The Marcy mill department of the Mace & Smelter Supply Company has moved from Salt Lake City to the Denver office. O. H. Johnson remains in charge of the department.

MEETING OF FERTILIZER COMMITTEES.—A subcommittee of the National Fertilizer Association recently met in New York with several fertilizer and chemical manufacturers, following conferences in Washington, and discussed plans for the supply and distribution of fertilizers. H. Ace Bowker, chairman of the subcommittee, presided at the meeting. All of the producers present were ready to place their plants at the service of the Government. One question of importance which came up was concerned with the supply of pyrites, of which 1,250,000 tons comes normally from Spain. The Government's reduction of shipping have cut down the imports. The manufacturers were told that steps were being taken to get domestic supplies. It was added that the shortage of sulphur, formerly obtained from abroad, was being remedied by increased American production.

GOLDSCHMIDT THERMIT.—The Goldschmidt Thermit Company, 120 Broadway, New York, announced in the last issue of *Reactions* that a Pittsburgh branch office of the shop would be opened in the near future in charge of H. D. Kelley, who has represented the company in that district since 1910. Edwin B. Bloom will also be attached to this office. The shop will carry a large stock of Thermit, crucibles, preheaters, wax, molding material, and in fact everything required for Thermit welding operations, and in the case of emergency customers will be supplied with from this store room and avoid the delay incident to obtaining shipments from Jersey City.

DYESTUFF PRODUCTION IN THE UNITED STATES.—The Bureau of Foreign and Domestic Commerce, with the cooperation of its district offices, has prepared a revised list of manufacturers in the United States producing coal-tar crudes, intermediates, artificial colors, and vegetable dyestuffs and extracts, copies of which may be obtained from the Bureau and its district and co-operative offices. Forms were prepared and sent to all manufacturers known to be interested in the industry, and the replies of the companies, none of whose incorporation have appeared in recent issues of the chemical trade journals. As the primary object was to secure an up-to-date commercial list of domestic manufacturers, there was no attempt to make a complete census or officially verify the data on production. The list furnishes the names, addresses, branch offices, factory locations, principal products, specialties, and future lines of development contemplated, when given, of 158 manufacturers, classified by production under the following headings: Crudes, 23; intermediates, 70; artificial dyestuffs, 99; vegetable dyestuffs and extracts, 18. Of the 80 forms returned, 26 omit the amount of capital stock, the remainder show an aggregate investment of \$100,878,500. Of the 26 firms that did not furnish this item, at least 8 are large concerns representing an additional capital investment of about \$20,000,000. Of the 78 firms included in the list, 13 are from which forms have not been received, data from trade journals and other sources indicate that 18 of them have a total capitalization of about \$4,000,000.

Of the 80 forms received 30 contain actual or closely estimated figures on output, although only partial returns are furnished for some items. From data given on these 30 firms, the following totals of current monthly production have been compiled:

No. of firms making	Products	Pounds.
16 Crudes:		
	Benzol, toluol and some xylol and phenol.....	\$41,200
	Naphthalene, tar, etc., acid, etc.	6,186,000
20 Intermediates		5,821,650
17 Artificial colors		1,138,100
11 Vegetable dyestuffs and extracts (including some tanning extracts which were not sent separately. Some plants not run during the year, but at present)		6,678,500

*Gallons.

These totals do not include returns from one of the largest manufacturers of crudes, two of the largest producers of aniline dyes representing over \$30,000,000 capital, and two of the most extensive plants making vegetable color. When compared with the census returns of the domestic dyestuff industry for the calendar year 1914, when there were only seven establishments with a total output of 6,678,500 lb.

LEEDS CHEMICAL FIRM BUYS COAL-TAR PLANT. Brotherton & Co. (Ltd.), of Leeds, a firm which manufactures ammonia and coal-tar products, has announced the purchase of the Mersey Chemical Works, built by the Badische Aniline & Soda Fabrick at Bromborough Port, Dirkenehead, near Liverpool, for the manufacture of aniline and other chemicals. The head office of the firm is quoted by the Yorkshire Evening Post, of Leeds, as stating that when the present extraordinary demand for high explosives has subsided, plant and material will be put to considerable extent to the manufacture of coal-tar intermediate products and dyes.

Brotherton & Co. (Ltd.) controls works established in chemical works as follows: Leeds, 1882; Stourton, 1888; Birmingham, 1893; Liverpool, 1904; Glasgow, 1904; Sunderland, 1905; Worthington, 1913; and Middlesex, 1914.

THE RUTH-LUND ASSAYING & METALLURGICAL COMPANY announces the opening of offices at 1727 Champa Street, Denver, Col. Mr. A. E. Lund was formerly with the United States Geological and Reclamation Co., and for nine years previous to that he was with the A. S. & R. Co. Mr. J. P. Ruth is engaged in mining at Idaho Springs, Col. The office is being equipped for metallurgical testing in addition to the chemical and assaying laboratories.

THE KALBLEISCH CORPORATION, 31 Union Square West, New York City, announces that all the assets and business of each of the Franklin H. Kalbleisch Company, Erie Chemical Works, Kaloid Com-

pany and Kalbleisch Corporation have been transferred to and taken over by the Kalbleisch Corporation, recently organized. In the future conduct of the consolidated business there will be no change of policy or management.

FERROSILICON.—The Keokuk Electro Metals Company of Keokuk, Iowa, for which the Goldschmidt Thermit Company is exclusive representative and sales agent, has been very successful in its production of 50 per cent ferrosilicon, according to *Reactions*, the Goldschmidt house organ. The plant at Keokuk has been in full operation for about six months and the material turned out is of exceptionally high quality. The Goldschmidt Thermit Company is now quoting on a limited quantity of this alloy for shipment during the first quarter of 1915.

RESPIRATORS.—The American La France Fire Engine Company, New York City, manufactures a respirator, known as the Hayward respirator, which is claimed to give adequate protection under all fume and dust conditions. Comfort to the wearer is obtained from the general design of the face piece and also from the pneumatic face cushion. The protection to the wearer is obtained by the double filtering device through which all air breathed by the operator is strained.

RESPIRATOR.—The Life Saving Devices Company, Chicago, Ill., has introduced a breathing device for use in poisonous gases. The device supplies fresh air to the wearer. It consists of six principal parts. 1, mouthpiece; 2, chest piece; 3, tube; 4, valve; 5, nose clip; 6, belt. The apparatus is furnished in a box, with reel for "paying out" the proper amount of hose.

BY-PRODUCTS FROM EXPLOSIVE MANUFACTURE.—Ernest Scott & Company, Fall River, Mass., are introducing equipment to be used in recovering by-products in explosive manufacture. The equipment is used in connection with benzol, toluol and alcohol recovery, and also pure liquid ammonia direct from the gas works and coke-oven liquor. T. N. T. is washed in alcohol and the equipment is used for the purpose of recovering from the washings and obtaining T. N. T. residue free from water in a fused condition. A special drying plant is also furnished for the final drying of the T. N. T. The plant for the manufacture of pure ammonia direct from the gas works and coke oven liquor is used for working up the crude liquor. It is claimed to produce continually in one straightforward operation a pure ammonia containing 30 per cent NH_3 and 0.2 per cent H_2S .

PLATINUM.—The United States alone annually uses about 45,000 ounces of fine platinum. It produces less than 100 ounces of crude platinum, according to the Geological Survey. Realizing the urgent necessity of increasing the country's production of this metal, the U. S. Geological Survey, Department of the Interior, has planned an investigation in which L. M. Smith, Chief Geologist, will visit various places in this country where commercial deposits of these metals may be found. Native platinum, the metal, and sperrylite (platinum arsenide) have been found in basic igneous rocks at several places in the world, but not in commercial quantities. The search for platinum in rocks is therefore not likely to obtain an immediate supply of the metal. Persons seeking platinum ores should remember, however, that the assay for platinum is difficult and apparently cannot be successfully made by the ordinary assay. A method of assaying supposed platiniferous ores should therefore be sent only to the most competent assayers. The United States Geological Survey has ordered that all reports of discovery of rich platinum ore in which the report states, "the platinum could not be detected by the ordinary methods of assay." Such statements should be regarded with great caution. The only platinum ore of commercial grade will doubtless yield traces of platinum if tested by the standard methods employed by competent and reliable assayers. The small quantities of the metal, except a relatively small quantity, have been obtained from placer deposits, notably from those of Russia, which have produced about one cent of the world's supply. The largest part of the crude placer platinum now produced in the United States is won by dredges working in California at the mouth of the San Sierra Nevada, in gravels derived from worn-down loaves and concentrated by natural streams. The greater production from this region than from northwestern California and southern Oregon and other places would appear to be due to larger operations rather than to greater or richer deposits. The adequacy of the future supply of platinum in the United States, as far as it can be

assured, depends on the results of work of three kinds—first, the determination of our present supply, particularly of unmanufactured platinum metals, in order that it may be mobilized; second, systematic search for new deposits; and third, the exploitation of the deposits discovered, to assure their maximum yield. Work of the first two kinds is now being done by the Geological Survey, and it is hoped that work of the third kind—the technologic work—may be in part done by means of Federal and private investigations. The above data do not take their scanty platinum produced by copper refineries and from platinum scrap, which furnish a considerable amount, but not nearly enough to supply the normal demand.

Manufacturers' Catalogs

ALLIS-CHALMERS MANUFACTURING COMPANY, Milwaukee, Wis., has issued Bulletin No. 1632, which describes their centrifugal pumps of all types and also pumping units.

LINK-BELT COMPANY, Chicago, Ill., has issued a number of new catalogs for 1917. Data Book No. 125 is a very attractive book describing silent chains, Book No. 305, 1917, describes traveling water gears for condenser intakes, Book No. 253, 1917, describes drives for cement mill equipment, Book No. 270 describes wagon and truck loaders for handling coal, coke, lime, sand, etc., and Book No. 260 describes classes of Link-Belt commonly used in saw mills.

PENNSYLVANIA FLEXIBLE METAL-LINE TUBING COMPANY, has issued a catalog which describes Pennsylvania metal hose.

ACIERAL COMPANY OF AMERICA, 26 Cortlandt Street, New York City, has issued a little booklet on "Acieral," a material described as having the strength of steel, lightness of aluminum and non-corrosive.

LIFE SAVING DEVICES COMPANY, Chicago, Ill., has issued an interesting booklet on "Life for the Men in the Trenches."

AMERICAN PULVERIZER COMPANY, East St. Louis, Ill., has issued Catalog No. 21 describing its pulverizers.

The B. F. GOODRICH RUBBER COMPANY has issued a catalog describing the many uses of Goodrich hard rubber goods.

WERNER & FLEIDERER COMPANY, Saginaw, Mich., has issued an attractive catalog describing "Universal" kneading and mixing machines.

THE MAGNETIC MANUFACTURING COMPANY, Milwaukee, Wis., has issued Bulletin No. 12 describing its type L Magnetic Separator with dynamo attached. The machine is made in five sizes and is applicable for use in a wide variety of industries.

THE U. S. BLOW PIPE & DUST COLLECTING COMPANY, 216-218 North Washtenaw Avenue, Chicago, has issued its catalog E. S. No. 2, describing its high efficiency, slow speed dust collecting systems for use in collecting dust in chemical, cement, paint, paper, furniture factories, etc.

Other New Publications

THE MINERAL RESOURCES OF OREGON.—A publication of the Oregon Bureau of Mines and Geology at Corvallis, Ore. This is a handbook of the mining industry of Oregon, giving an alphabetical list of properties, descriptions of mining districts, by H. M. Parks and A. M. Swartley.

ZINC AND CADMIUM IN 1915. Production and Resources, by C. E. Siebenthal, published April 30, 1917, by the Department of the Interior, Washington, D. C.

TESTS OF CLAY MATERIALS AVAILABLE IN ILLINOIS COAL MINES, by R. T. Stull and R. K. Hursch of the Ceramics Department of the University of Illinois, published by the Illinois State Geological Survey.

SANDSTONE QUARRYING IN THE UNITED STATES. By Oliver Bowles, Bulletin 124, Mineral Technology 17, published by the Department of the Interior at Washington, D. C.

AMERICAN GIBBERTAL—MUSCLE SHOALS.—A brief for the establishment of our national nitrate plant at Muscle Shoals on the Tennessee River. Prepared by Nashville Section, Engineering Association of the South, Published by Muscle Shoals Association, Nashville, Tenn.

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Contents for June 15, 1917

EDITORIAL:

Tendencies in the Zinc Industry.....	673
Impurities in Electrolytic Copper Refining.....	674
Our Economic Future	675

READERS' VIEWS AND COMMENTS:

A Great Library of Applied Science. By Kenneth C. Walker	676
Coming Meetings and Events.....	676
Mining Engineers Discuss War Problems.....	676
The Court of Appeals Decision in the Miami Flotation In- fringement Case	677
Meeting of New York Section of American Chemical Society.....	677
Metallurgists Needed by the Government.....	678
Third National Exposition of Chemical Industries.....	679
Osmotic Pressure. Discussion Before Faraday Society.....	679
Annual Meeting of Iron and Steel Institute in London.....	682
Leads for Electric Furnaces. By Prof. Arvid Lindström.....	683
Impurities in Electrolytic Copper Refining. By Lawrence Addicks	687
The Testing of Lubricating Oils. By Hugh K. Moore and G. A. Richter	692
Producer Gas and Its Industrial Uses. By F. W. Steere.....	695
Recent Developments in the By-Product Coking Industry of Japan. By T. Kurahashi	700
Potash from Cement at the Riverside Portland Cement Co.....	701

SYNOPSIS OF RECENT METALLURGICAL AND CHEMICAL LITERA- TURE	704
RECENT METALLURGICAL AND CHEMICAL PATENTS.....	706
The Supply of Platinum.....	708
A New Dry Concentrator.....	709
Oxy-Illuminating Gas Lead Burning Apparatus.....	709
A New Hardness Tester.....	710
Cooling Condensing Water in a Dyestuff Plant.....	710

PERSONAL	711
BOOK REVIEW	711
Current Market Reports—Iron and Steel, Non-Ferrous Metal and Chemical Markets and Chemical Price List.....	711
Industrial—Financial, Construction and Operation and Manu- facturers' Notes	715

Tendencies in the Zinc Industry

Philosophers long ago observed that life is motion and motion life and that consequently things are always in a state of flux. This is analogy built on the laws of physics, which is the science of motion. As analogies go it is a broad, pervasive and accurate analogy. We may then consider that Newton's three laws of motion govern the world of men, women, and things, as well as the world of mass, velocity and acceleration. Of these three laws, the last, that to every action there is an equal and opposite reaction, applies positively to the zinc business at present; and this law finds its counterpart in Emerson's law of compensation.

In what might be termed the metallurgical economics of zinc these two laws, or rather this law in dual form, applies peculiarly, particularly and precisely. It applies peculiarly for the reason that the zinc business is always in a state of kinetic growth and in actual tonnage there has been but one set-back in twenty years. It applies particularly because in the past two and one-half years there has been a period of abnormal growth or a positive action while the reaction is just starting strongly. It applies precisely because both the action and the reaction can be seen by anyone with extreme clearness.

We know that beginning in January, 1915, a period of intense demand raised the price for spelter which continued with a major swing until June of that year and in its minor swing to the middle of 1916, and that for the past twelve months zinc while low compared with the unprecedented maximum is still nearly double the thirty-year average.

During the first two periods the smelter's margin, which is normally only a few dollars per ton of ore, rose to the unheard-of figure of 70. Now this was enormous. New retort plants were built like six-family tenement blocks, against the advice of the conservatives. Straightway, they paid for themselves in two months. Mines, too, shared in the prosperity, for ore rose in price. New mines paid fabulous dividends. Old mines paid even greater. Never was a boom seen in such glory—never was it so plain. It was a fairy-tale; but the statistics proved its reality. For years to come, professors of economics can use it as the typical and classical boom. Price, production, consumption and smelting capacity broke all records.

Now, in this time of inflation, there were sown the seeds of trouble. Chief of these was labor. Whereas the job of condenser cleaner or "connie-boy" paid in 1897 \$1.15 per day, in 1907 \$1.65, in 1917 these young

and unskilled laborers received the aristocratic salary of \$4.15 a day. All other furnace labor requiring more skill and experience has increased and in three years the cost of labor per ton of ore has doubled. Next after labor, fire-clay has become poorer in quality and higher in price. Coal and gas tell the same story. Now while the smelter's costs have increased his margin has decreased. The consequence is that a number of retort plants have shut down, simply because they saw no prospects of making money in the future and left the field to the newer and more efficiently situated plants.

The smelting plants have made efforts to ameliorate their situation by smelting lower-grade ores, in which there was a large margin. This is reflected in the statistics, which show a steady decline in the amounts of spelter made each year per retort. On the other hand, the capacity of the retort has been increased by reason of "heavy charging" and the use of extra men to chisel out the slag formed in the retorts.

During the last two years the recovery of zinc in the reduction process has been abnormally low. Generally it was better business to force the tonnage, waste some zinc, in order to gain spelter. Losses of 25 per cent and even 30 per cent were not uncommon and not unprofitable, when a furnace was being charged with 22,000 lb. or even higher of oxidized ore, as compared with charges of 16,000 lb. in the earlier days. But to-day losses are often what Mr. Ingalls calls little short of a metallurgical crime.

What the future will bring to the zinc business is an uncertain but interesting proposition. A few things are certain. The first of these is that while furnace labor will gain in efficiency, as indeed it is now daily gaining, it will not be materially cheaper than at present. The metallurgical efficiency, or the skill with which the ore is calcined, blended and mixed with coal, will surely be increased. Fire-clay we know will be improved. Devices like equalizing furnaces with machine molding will be installed. There will be consolidations of existing plants with a general staff of consultation and direction, although the tendency in the zinc business is usually along the lines of individualism. Larger retorts, with machine charging and discharging, will be in cases factors making for amelioration.

As zinc is such an essential raw material for war, we can perhaps expect some sort of government control or supervision to stabilize conditions and make for an increased output. The actual competition of the electrolytic zinc plants and the potential competition of other lines of improvement such as the electric furnace must tend in the run of future time to keep the margin of the retort plant small. As most of the mining and smelting companies have made a great deal of money in the past two years, the funds for developmental work are present.

Perhaps the largest field for the retort plant to save lies in the recovery of values in the residues. The field for this is large and sure. With the recovery of

zinc as an oxide, blue-powder or metal, to be sold for commercial purposes, to be used by the electrolytic plant or by the retort plant itself, and with the saving of the values in lead, copper, gold and silver, the economy to the retort plant would be great and appreciatively regarded.

Such an operation would be like the use of the flotation cell in connection with a concentration plant or of the low-pressure turbine in connection with a steam-engine plant.

But we can certainly say that the retort plant is facing the dilemma of increasing costs and decreasing margin. Possibly it is facing a fate similar to that which the steam-engine did twenty years ago. Then the steam-turbine and the gas-engine were coming on the scene. The past decade has told of their success as prime-movers. It is possible that several of the other avenues of zinc-reduction will tell their own story. But just now the retort plant is faced with a hard proposition. And the men making zinc are men and will face in a manly way the action of the great law of compensation. Explicitly, this is that if a man absorbs too much of a colored and flavored solution of ethyl alcohol, the bed will go round at night and in the morning there will be no disputing about the taste of gamboge or sienna in the upper regions of the esophagos. In short, and in physics, to every reaction there is an equal and opposite reaction.

Impurities in Electrolytic Copper Refining

Like all articles in Mr. Lawrence Addicks' remarkable serial on electrolytic copper refining, his article published elsewhere in this issue, on the handling of the impurities in copper refineries, is noteworthy and instructive in more than one respect. It states the problem—or problems involved—very clearly, and likewise the change of the problem with the change in smelter practice. It outlines concisely, with equal clarity, the different solutions of the problem worked out in actual practice, whether arsenic or nickel is the controlling impurity. It also brings out clearly the fact that while copper refining is theoretically very simple in its underlying principle, yet in practice, where all the many little details count, it is a very complicated matter; it is a whole art and science in itself, and we are sure that the whole metallurgical profession will feel under obligations to Mr. Addicks for his truly authoritative critical statement of the present status of this important art and science.

The problem of handling the impurities is absolutely fundamental in all wet processes. The process of the operating man is twofold: first, to get the initial starting conditions of operation right; second, to maintain the conditions right during operation. The first is simple, because the choice of the starting conditions is absolutely in the hands of the operator. The second is difficult, because the operating man has no longer the same free choice; he has a given system, and as soon as electrolysis starts things happen in his system

and his system changes from moment to moment, and new things happen, and so on. By the very rationale of the whole process, impurities will go into the electrolyte. Yet to achieve success, these impurities must be controlled. As David H. Browne once said, everything can be done with pure solutions, nothing with foul ones, and eternal vigilance is not only the price of liberty but of the success of electrolytic processes. No wonder here was a serious handicap, and for a time all wet processes were under suspicion. Anton Eilers, with characteristic frankness, once spoke of wet processes as metallurgical Schweinereien, indicating that the fouling of solutions did not fit his aesthetic ideals of a clear-cut metallurgical process. But, after all, the wet process has won out, at least for metal refining. And while leaching processes are a more difficult proposition, we expect to see interest in them revived when once the full possibilities and limitations of flotation are finally established.

Our Economic Future

Early in January, 1916, Chairman Gary of the United States Steel Corporation issued a statement as to the condition and prospects of the iron and steel industry, saying of industry in general: "There is great expansion at present. I fear there is great inflation." He counseled a "stop, look and listen" policy. Steel prices were then equal to the high prices reached in 1907, the highest since 1902. Now steel prices are \$50 per net ton higher. The next month Sir George Paish, editor of the "Statist," and financial adviser to the British Government, furnished an elaborate article to an American paper in which he made what nearly everyone in the United States considered a very remarkable statement: "The idea that the United States is deriving or can derive any advantage whatever from the war is a complete delusion. All that is happening to the advantage of your country is that it is suffering less than the belligerents as a result of this titanic contest."

Now that we are in the war what would Sir George say? What would Judge Gary say now when steel prices are more than double the prices at the time he counseled caution?

When a country engages in successful war it is the patriotism of those who go to the front that saves it from defeat and the practical patriotism of those who stay at home that saves it from economic ruin. There is an immense economic loss in the time and materials consumed in waging war, so great a loss that it could not be made up except by those at home consuming less and producing more. The people must give up their luxuries and waste less. The women must knit socks instead of playing bridge. The children must play gardening instead of playing something useless. Men must work overtime, and so all along the line.

Undoubtedly we are much less selfish now that we are at war. We may feel entirely unselfish, and yet the advent of war does not destroy the personal viewpoint acquired in years. There has been complaint as to the magnitude of the war taxes Congress has been consid-

ering on the ground that too much taxation would spoil business and then there would be nothing to tax. Silas Wegg wanted Mr. Boffin to pay for the suppression of the will all that its publication would take from him, but Mr. Venus urged that Boffin ought to be left something to make it worth his while, even as much as half, and Congress has taken an even more liberal view than Mr. Venus. It will still be worth while for business to run along.

War taxes, war loans, and everything else connected with the war should be conducted not to preserve business but to preserve industry. In the practical application there is unfortunately a difference. The question works down to the individual. Matters should be so arranged that every individual should produce the maximum of the most useful things, and should consume, or destroy, as little as possible.

Since the war began there have been real profits for many individuals and there has been an apparent profit to the country as a whole through the favorable merchandise trade balance, some five billions or thereabouts. There is doubt whether this is not partly a paper profit, but what is certain is that the material wealth of the country, if it has increased at all, has not increased as rapidly as it does in peace times. There has been some new construction, but it has been largely for the production of war material, of no value when war is over. The five billions or so by which we have improved our financial relations with the rest of the world is something like 2 per cent of the country's material wealth. During nearly three years of war the retardation the war has caused to the increase in our material wealth has been much greater. Economically we are much poorer than if the war had not come.

Physically we have lost very greatly, just as Sir George Paish said. Mentally we have acquired a great deal but what we have acquired will be no gain unless we use it, of no more economic value than an unworked patent. Many bad habits were acquired. Workmen, given wages at undreamed of rates, have become extravagant. Many business men who acquired wealth dreamed of the ease and luxury that would follow their few years of stress. Our own entrance into the war will largely prove an antidote to these infections. Everyone must work harder and we must endeavor to make materially productive the new ideas the war has given us. Our economic position has been impaired, and work, to balance the waste, is the only thing that will restore it. There is no occasion to worry about the situation immediately after the war. Experience shows that what are called "good times" always follow war. After those "good times" there always come "bad times." The lesson men have never learned before is that there really must be something bad about "good times" if they are followed by bad. The goodness is not entirely of the right sort. Too much of the apparent goodness is made by reckless investing or plain reckless spending. Economy and efficiency need to be continued after the war, that the times may be really good and not store up trouble for the later period.

Readers' Views and Comments

A Great Library of Applied Science

To the *Editor of Metallurgical & Chemical Engineering*
SIR:—That America has the largest engineering library in the world is excellent. That America should have a large chemical library is manifested in the editorial of your last issue.

It is to be hoped, however, that the ideal of a single large collection of engineering and chemical books should not stop at the gathering together of one single library in one single city. The ideal to strive for upon the completion of a large and, let us say, parent collection, should be for a group of co-ordinated highly technical libraries. By technical libraries I have in mind society, college, public and business house libraries.

Some little time ago, in fact in the *Engineering Record* for March 20, 1915, there appeared an excellent editorial on "The Work of Engineering Libraries." The text of this rather long and to a degree, technical article was summed up in the following: "There are in this country a large group of engineering libraries of great value *collectively*, but not yet suitably *co-ordinated*. Of course the splendid collections of the engineering societies in New York city . . . form a source comparatively accessible to those in the immediate vicinity. In other cities special libraries exist which probably contain unique matter of great value. . . . United effort is just beginning to take effect, and efforts are being made to furnish bibliographical and other information. . . . *The trouble is that these efforts are generally individual and have not been fully correlated.*"

In the above article is to be found a pointer for a great effort to be launched for the establishment of a suitable powerful directing head with well chosen units throughout the United States.

For some time the writer had kept in mind the article just quoted from the *Engineering Record*, and at every opportunity talked with other librarians doing technical work, either in public libraries or industrial houses, as to the possibility of launching a co-ordinating movement. It was hoped that the Special Libraries Association, composed of librarians in public, college and industrial houses, might officially undertake this work. To that end the writer was asked to read a paper on "Co-operation Between Libraries and the Engineering Profession."

After considering the subject and drawing together facts on paper, the writer sent the first draft to several technical librarians for suggestion and approval. I may be pardoned, then, if I quote the part that appealed to these librarians, on the ground that it has some worth to it. These librarians were, by the way, actively engaged in industrial or society library work.

The part which appealed to them was the summary. To quote, "There should be a committee chosen from this association (the Special Libraries Association, which might now be changed to representative technical librarians, owing to lack of funds for the Special Libraries Association to initiate a committee) with a possible advisory or consulting committee of interested engineers; (2) this committee should work on a roster of sponsored libraries and the published official list distributed widely; (4) the publication of an index of at least the important works of each sponsored collection; . . . (6) education of the clientele in the use of the established library service; (7) the consideration of a short course based on a study of the practice fol-

lowed successfully for over two years by Mr. Hendry of the Applied Science Room of the Pratt Institute Free Library, in exchange for the unorganized inefficient instruction now carried on by several of the engineering schools; (9) rounding up of all additional sources of information (other than libraries); (10) well directed publicity."

The greatest strength and usefulness of a "Great Library of Applied Science" lies in a parent library with well chosen units in well distributed localities of the United States.

KENNETH C. WALKER.

Pittsburgh, Pa.

Coming Meetings and Events

American Institute of Chemical Engineers, semi-annual meeting, Buffalo, June 20-22, 1917.

American Society for Testing Materials, Atlantic City, June 26-30, 1917.

American Chemical Society, Boston, Sept. 10-15, 1917.
Third National Exposition of Chemical Industries, Grand Central Palace, New York, week of Sept. 24, 1917.

American Institute of Metals and Foundrymen's Association, Boston, week of Sept. 24, 1917.

American Electrochemical Society, autumn meeting, Pittsburgh, Oct. 3-6, 1917.

American Institute of Mining Engineers, annual meeting, St. Louis, Oct. 8-13, 1917.

Mining Engineers Discuss War Problems

Meeting of New York Section of A. I. M. E.

The New York Section of the American Institute of Mining Engineers held a meeting at the Machinery Club in the Hudson Terminal Building on Wednesday evening, June 6. The meeting was devoted to patriotic addresses and to the discussion of plans for aiding the Government in the present crisis.

A business meeting was held at 6.15 p. m. preliminary to the regular meeting, at which officers were elected for the coming season as follows: Chairman, J. E. Johnson, Jr.; vice-chairman, Edgar Rickard; secretary, D. M. Liddell; treasurer, C. A. Bohn. Dinner was served at 7 p. m.

The first speaker was Major George H. Putnam, retired, who delivered a fine patriotic address. He was followed by Captain Dulieux, a member of the French purchasing commission stationed in New York and also a member of the Institute. Mr. Drucker, a member of the Mining and Metallurgical Institute of London, followed. The last two talks were in the nature of greetings from the allies.

It was decided to continue the meetings throughout the summer, and to take up subjects of importance in the present crisis. Representatives of the Government will be asked to address the meetings in order that ways and means may be found for co-operation. At least two or three meetings are planned for the summer.

An announcement of special importance was made at the meeting by Bradley Stoughton, secretary of the Institute. He said that the Mechanical, Electrical and Mining Societies had decided to entertain Dr. Guglielmo Marconi at a dinner, the date of which will be announced later.

The Court of Appeals Decision in the Miami Flotation Infringement Case

In our issue of June 1 we clearly stated the gist of the important decision of the Court of Appeals in Philadelphia, showing that while the majority opinion of the court, written by Judge Wooley, was technically in favor of the plaintiff (the Minerals Separation) it also appeared to be practically a vindication of the Miami present operating practice, since the three elements which the court decreed as infringing the patents in suit are, in fact, not a part of their present operating practice, but were indeed features of the experimental plant in the experimental stage of the process.

The majority opinion of Judge Wooley, as well as the minority opinion of Judge Buffington, also appear very clearly to sustain the defendant's position as to the limiting character of the U. S. Supreme Court decision in construing patent 835,120 in the Hyde case.

Minerals Separation contended that the Supreme Court had no intention of limiting the patent to any especial violence or duration of agitation, but that its decree was based upon the *critical* amount of oil.

The defendant, upon the other hand, argued that the Supreme Court had found that patentability resided in a combination of the three elements, critical amount of oil, violence and duration of agitation greater than previously disclosed, and resulting froth of a peculiarly persistent character, differing in that from any froth disclosed in the prior art.

As to these conflicting contentions, the majority and minority opinions both seem distinctly to sustain the contention of the defendant, the Miami Copper Company.

Judge Wooley, whose opinion is for the plaintiff (Minerals Separation), technically speaking, since he finds infringement of the patents by the defendant is very clear in his statement referred to in our last issue, "If the only agitation to which the pulp was subjected (after such agitation as in the prior art was necessary to mix the oil and ore) was the agitation of the Callow cells, we would not say that that agitation amounted to or was the equivalent of the violent agitation of the patent disclosure, and constituted infringement; but in the process we are considering, and upon which the decree we are reviewing was based, the Callow cells were not the whole process, but were merely the last of four distinct parts of the process, the other three being the process of the patent or its fair equivalent. Having used the process of the patent in the first three steps in developing the potentiality of the critical quantity of oil and air, and bringing the pulp to a point where, if permitted, it would produce the result of the patent, we feel that the defendant cannot escape infringement by taking an additional step, even though that step, if taken alone, voids the patent."

Judge Wooley clearly indicates here that the Callow cell does not infringe. He also previously stated: "It is equally true that in this fourth step, aeration is direct and is not the result of or caused by agitation. On the contrary, agitation results from aeration, and such agitation, though present in some measure, is not even approximately of the violence and duration of the agitation of the patent. The operation in the Callow cell certainly possesses these distinguishing features from operation of the process where aeration is caused by agitation." Judge Wooley asserts—as the quotation shows—that this expression of the facts is true ("equally true"), the other truth referred to being that the foam immediately subsides upon shutting off the air, and does not arise as it did when "agitation" was arrested.

We do not understand Judge Wooley's statement "that before the Callow cell (or Bubbles tank) is called upon to perform its task, the pulp is always pre-agitated and pro-aerated in some fashion and to some extent." He cannot have overlooked the experiments before the Appellate Court, especially the final experiment, in which the pulp, before charging into the Bubbles machine, was very gently rolled in a bottle so as to produce no froth, and that absence of froth was particularly called to the court's attention. He may have excluded this from his consideration, possibly not having noticed its counterpart in the very voluminous record of the court below, upon much the same principle as he excluded what he calls the fourth process, as he describes the present practice at the Miami mill.

Judge Buffington, in his minority opinion, quotes voluminously from the records and testimony of the discoveries of the process as to the violent mechanical agitation being a requisite. Judge Buffington does not find agitation of this violence or duration in either of the three features considered as infringement by Judges Wooley and McPherson. In everything else they appear to agree.

Contrary to the expectations expressed in our last issue, there has not yet been made, as far as we know, any motion for rehearing or appeal, and it has even been thought possible that there is no necessity for such appeal on the part of the defendant.

Meeting of New York Section of American Chemical Society

The New York Section of the American Chemical Society held its eighth regular meeting of the season in Rumford Hall, Chemists' Club, on Friday evening, June 8. The vice-chairman, Dr. F. J. METZGER, presided in the absence of the chairman, Dr. J. M. MATTHEWS. The meeting and the dinner preceding were very well attended.

Coloring Glass by Short Wave Lengths of Light

The first paper of the evening was presented by HARRY ROSENTHAL of 52 East Forty-first Street, New York City, on a new process of coloring glass by short wave lengths of light, *i.e.*, rays produced by the ordinary quartz mercury arc, an X-ray tube, the Coolidge X-ray tube and a special X-ray tube for producing negative electrons.

Previous writers have recorded the beautiful tint and colors assumed by some grades of glass when exposed to the sun and weather. Photographers had noticed that a different time of exposure was required in taking pictures under skylights as the skylights became old. Experiments showed that the change in color in the skylight glass absorbed an appreciable amount of the actinic rays.

The author's first experiments were carried out about eight years ago with an ordinary X-ray tube and induction coil. A faint color was noticed in the glass after about two days' time. The special water-cooled, self-rectifying tube developed by Dr. Coolidge of the General Electric Company proved a much better apparatus and definite results were obtained with this machine. Following the use of the Coolidge tube a special X-ray machine was used. This latter apparatus has a vacuum tube about 4 in. in diameter, with an anode of solid tungsten supported on a rod of molybdenum, and a cathode consisting of a tungsten spiral which can be electrically heated. The vacuum of this bulb remains constant, the penetration of the tube being governed by the heat of the cathode spiral. Unless

the filament is heated the tube shows no conduction in either direction, even with voltages up to 100,000. In coloring optical lenses a light color can be obtained in two minutes with 100 milli-amperes and 50 kilovolts. In four minutes a medium color is obtained and in ten minutes a dark color. By controlling the penetration of the rays, by varying the voltage, different degrees of color can be obtained.

The author showed several samples of glass colored by this method, including optical wedges and optical lenses of amethyst, amber, green and yellow tints. Some specimens of Kunzite (a semi-precious stone) were also shown which had been changed to emerald green. He stated that porcelain teeth could be colored by placing a wedge of aluminium on the teeth, and that porcelain ware can be colored with designs by placing stencils on it.

The coloring of the glass is believed by the author to be due to a physical change in the material, since by heating the glass will resume its former color. The coloring of the purple glass is undoubtedly due to manganese, and the other colors are analogously obtained.

In discussing the paper Dr. Chas. Baskerville asked whether glass so colored would be of practical use in glasses for furnace work. Mr. Rosenthal replied that the amber-tinted glass was valuable for this purpose. He also stated that amber-tinted lenses were used by the Government for binoculars for use in foggy weather. It was also asked whether the colloidal theory had been considered in connection with the reason for the coloring—that is, whether colloidal metals which would produce the color were set free by the action of the light. Mr. Huston said the term colloid was like the word catalysis. He said the latter word had been defined by a former classmate of his as a phrase used by chemists to hide their ignorance.

Preparation of Pure Molybdenum

The second paper was presented by C. H. HUMPHRIES of the Commercial Research Company, Long Island City, N. Y., on "Molybdenum." His talk was devoted chiefly to the preparation of pure grades of molybdenum.

He reviewed briefly the geology of molybdenum ores and showed samples of molybdenite and wulfenite. Molybdenite, MoS_2 , is the principal source of metallic molybdenum. It is reduced by carbon in an electric furnace. The ordinary methods, however, produce a metal which contains some carbide, and in order to obtain pure molybdenum the trioxide or ammonium molybdate has generally been used, as the starting point. The molybdate is made from the sulphide and this is reduced in an atmosphere of hydrogen in an electric furnace, producing a crystalline material which passes through several more stages of purification. The process is analogous to the well known General Electric tungsten reduction process.

This crystalline product is placed in a nickel or nickel-plated boat in a gas furnace and heated to 900 to 1000 deg. C. It is then crushed and screened and reduced again for several hours at 1200 deg. C. It is then examined for oxide by inspection. It appears streaky if oxide is present. If a blue tint is observed on shaking in water oxide is present.

It would be desirable to reduce finally near 1400 deg. C., but there is danger of the material becoming contaminated with iron if a nickel-plated iron boat is used. It is desirable to have less than 0.01 per cent of iron if molybdenum wire is to be made.

After the final reduction the metal is powdered, then pressed in a steel mold and heated in an electric furnace for about a half hour at 1200-1300 deg. The

metal sinters and becomes hard, but is not yet suitable for working. It is then placed in a furnace, the air displaced and a current of about 100 amperes is passed through the metal. It shrinks and forms a true molybdenum rod. It is then swaged and made into smaller rods, wire, foil, etc. The swagging is done hot from the electric furnace at about 1400 deg. The metal runs through dies of high speed steel down to 0.001 in. The smallest size for practical purposes is 0.005 to 0.01 in.

If the pure metal is heated to 1200 deg. several times and quenched the surface can be made glass hard.

In discussing the effect of alkalies, the author said that some molybdenite contains calcium and barium, and that these are hard to keep out of the metal. They prevent working of the metal when present even in the hundredths of a per cent.

The author mentioned an interesting possible use of pure molybdenum, i.e., as a substitute for platinum in jewelry. It is just as beautiful and is permanent and can be produced at present for 25 cents per gram. The main drawback is the difficulty of soldering. It can be welded in an atmosphere of hydrogen, but the method is cumbersome. Another possible use is in X-ray targets. The oxide is used with tannic acid in coloring shoes.

In the discussion following the paper Dr. Herty asked whether any jewelry had actually been made from molybdenum. Mr. Humphries said that experiments were in progress, and that he hoped to have definite results to announce before very long. Dr. Baskerville said he had used nichrome wire at the College of the City of New York for the students as a substitute for platinum in making flame tests, and that he was having some molybdenum wire drawn with a thin film of platinum on it for this same purpose. Mr. Humphries said the platinum and molybdenum could be worked very well together.

Metallurgists Needed by the Government

The United States Civil Service Commission announces open competitive examinations for metallurgists as follows:

A vacancy in the Springfield Armory, Ordnance Department at Large, Springfield, Mass., at \$3,000 a year, and future vacancies requiring similar qualifications, at the Springfield Armory or elsewhere, will be filled from this examination.

The duties of this position consist in the superintendence of the acceptance tests of steel and oil, and of the heat treatment of dies and tools.

The applicant should have had experience in the chemical analysis and the photomicrographical examination of steel, and in the prescription and supervision of the heat treatment of tools.

A vacancy in the department of ordnance, navy yard, Washington, D. C., at \$2,000 a year, and future vacancies requiring similar qualifications throughout the United States will be filled from this examination.

The duties of this position will be the laboratory control of: The melting operations in the manufacture of open-hearth, converter, and electric steel castings and ingots; nonferrous mixtures; the heat treatment of forging and casting of both alloy and carbon steels; the interpretations of physical and chemical tests and their application to shop operations.

Until further notice and on account of the urgent needs of the service, applications will be received at any time and the papers will be rated immediately upon their receipt, in order that appointments may be made with the least possible delay.

This examination is open to all male citizens of the United States who meet the requirements.

Applicants for these positions will not be assembled for examination but will be rated according to their education and practical experience in the subjects designated.

Applicants should at once apply for form 1312, stating the title of the examination desired, to the Civil Service Commission, Washington, D. C.; the secretary of the United States Civil Service Board, postoffice, Boston, Mass., Philadelphia, Pa., Atlanta, Ga., Cincinnati, Ohio, Chicago, Ill., St. Paul, Minn., Seattle, Wash., San Francisco, Cal.; customhouse, New York, N. Y., New Orleans, La.; Honolulu, Hawaii; old customhouse, St. Louis, Mo.; Administration Building, Balboa Heights, Canal Zone; or to the chairman of the Porto Rican Civil Service Commission, San Juan, P. R. Applications should be properly executed, excluding the medical and county officer's certificates, and filed with the Civil Service Commission at Washington as soon as possible.

Third National Exposition of Chemical Industries

The Third National Exposition of Chemical Industries will be held at the Grand Central Palace, New York, during the week of Sept. 24, 1917. Preparations are in active progress, with an advisory committee composed of Chas. H. Herty, chairman; Raymond F. Bacon, L. H. Baekeland, Henry B. Faber, Colin G. Fink, Bernhard C. Hesse, A. D. Little, R. P. Perry, Wm. Cooper Procter, E. F. Roeber, G. W. Thompson, T. B. Wagner, Uley Wedge and M. C. Whitaker. The managers, Charles F. Roth and F. W. Payne, report that the exposition will be larger and more interesting this year than its predecessors. At the close of the past exposition much of the space available on the two floors then used was re-engaged by the exhibitors for this coming exposition. At the present time these floors are completely taken and the greater part of the available space on the third floor has since been engaged.

A large section of exhibits showing the industrial opportunities the South presents in its many raw materials will be known as the "Southern Opportunity Section." A "Paper and Pulp Industry Section" has been provided and many elaborate exhibits are in preparation for the paper men when the Technical Association of Pulp and Paper Industry members visit the exposition again this year.

Other exhibits will be of interest to men from the rubber and textile industries. Many more dyestuffs companies have engaged to exhibit their products than formerly. Many of the chemical and allied industry companies have so expanded their operations in the past year, and their products and interests have become so numerous that they require much additional space to make adequate showings.

The Bureau of Commercial Economics at Washington is this year again preparing many of the motion picture films that will be shown at the exposition, and many exhibitors have now in preparation pictures showing phases in their work in the manufacture of their products. These will be of great interest, inasmuch as many are of processes that have been photographed for the first time, and their first showings will be made at the show.

The program of speakers has not yet been announced, but we are informed that it will be composed of many of the nation's foremost men, and men who have come to the fore in the nation's hour of need.

Osmotic Pressure

Symposium Before Faraday Society

The eighty-third ordinary meeting of the Faraday Society was held on Tuesday, May 1, 1917, in the rooms of The Chemical Society in London. The meeting was devoted to a general discussion on osmotic pressure. Sir Oliver Lodge presided.

Sir Robert Hadfield, president, in opening the proceedings, said he only did so in order to introduce Sir Oliver Lodge into the chair. Speaking as a metallurgist, he hoped that consideration of the subject under discussion would be found to have some bearing on the scientific problems of ferrous-metallurgy, such as the solution of carbon in iron.

Sir Oliver Lodge referred in the first instance to the general importance of the subject in animal and vegetable economy. That was the practical side; but the discussion was to concern itself with the theoretical side. Osmosis depended essentially on molecular discrimination, and this brought it into relation with evaporation and freezing. The subject could be treated either thermodynamically—disregarding what actually goes on—or from the kinetic standpoint, and that was how the authors of the papers would treat it, Dr. Porter applying the gas theory to the dissolved substance, Mr. Bousfield to the solvent, and Dr. Tinker dealing with the matter on a cohesion basis.

Prof. Alfred W. Porter opened the discussion by the presentation of his paper.

The investigations of Perrin and others upon Brownian motion have demonstrated once for all that the molecular translatory agitation in a liquid is precisely that which is given by gas theory. This had long been suspected but never proved. In considering a solute the dynamical effects of this motion must be taken into account; when the solution is dilute it comes out equal to the experimental value of osmotic pressure. Any other theory of osmosis must not only explain it, but at the same time must *explain away* the effects of molecular agitation. Of course, when the processes by which the final equilibrium state is set up, or the properties of the membrane which make it semipermeable, come to be examined, many interesting connections will certainly be found which will make it possible to express osmotic pressure in terms of them; but the *causa causans* of the whole phenomenon is the molecular bombardment of the solute, and a knowledge of this provides us with the *only way* in which the value of the pressure has been calculated from any direct theory of the mechanics of the solution. The properties of the membrane form a subsidiary problem; they have as much to do with osmotics as the properties of a glass vessel have upon the origin of the pressure experienced from water contained in it.

The experimental values of Lord Berkeley and Morse and their co-workers for sugar solutions can be approximately represented by a formula of Hirn's type, $P(v - b) = RT$; but the values of b are larger than the volume occupied by the sugar itself. The excess can be attributed to water of hydration. The hydration number found in this way from Morse's determinations diminishes with increase in temperature and also with increase in concentration. The extreme values are 53 and about 3. The value 53 occurs only in a very dilute solution, and the corresponding value obtained from Berkeley's experiments is only 14, which seems a more likely number. If the molecules of sugar and water are represented by spheres of volumes equal to their molecular volumes, between 30 and 45 molecules of water would form a single layer on each sugar molecule. It is exceedingly likely *a priori* that the water round a sugar molecule tends to form a condensed layer

on it which will be continually breaking up under the influence of molecular collisions. There is nothing in osmosis to indicate the degree of association of water molecules with each other; mono-, di-, tri-hydrol are indistinguishable.

Doubt is thrown upon the meaning of the symbol N in Poynting's and Callendar's modifications of Raoult's equation. Their theories require that N shall be the total number of real molecules of solvent, whereas thermo-dynamical theory and experiment require that it shall be the number reckoned as of the same complexity as in the vapor state.

Osmotic pressures can be obtained indirectly from vapor pressures by an exact relation first given by the opener; this has been done experimentally by Lord Berkeley. They can also be obtained from latent heats of dilution either by an exact formula given by the opener or by a better-known approximate formula—

$$H_1 = u T^{\frac{\delta}{\delta T}} \left(\frac{P}{T} \right).$$

Values of H_1 are being determined by D. O. Wood; some of these are published now for the first time, and Morse's determinations are checked by them. This mode of indirect determination of osmotic data is very exact because H depends only upon *deviations* of P from the perfect gas law, being zero when P is proportional to T .

Dr. F. Tinker then presented a paper on "The Colloidal Membrane: Its Properties and Its Function in the Osmotic System."

In this contribution the kinetic side of the subject of osmosis is developed by the aid of data obtained from the experimental study of colloidal membranes. Evidence is brought forward to show that moisture flowing through a semipermeable membrane is absorbed or superficially condensed on to the surfaces of the colloidal particles composing the film for such time as it is in contact with the membrane.

Generally speaking, osmotic flow takes place from a pure solvent to a solution because the pure solvent induces a greater pressure of concentration of moisture inside the membrane than the solution does. The condition for osmotic equilibrium is uniformity of moisture pressure and concentration within the membrane. To establish this uniformity, a hydrostatic pressure has usually to be placed on the solution in order to bring the moisture pressure generated by it inside the membrane up to that generated by the pure solvent. The particular hydrostatic pressure which does this is defined as the osmotic pressure of solution.

The evidence adduced points to the conclusion that osmotic diffusion is a process similar in character to, but *not* identical with, the process of vapor distillation. The main difference between the two processes is that the moisture within a membrane is in a much more concentrated condition than it is inside the vapor phase proper. But the resemblance is so great that for purposes of argument and mathematical treatment we can replace the actual membrane by a vacuum; at least this is the case when considering quantities, such as the magnitude of the osmotic pressure, whose value is independent of the nature of the membrane. By means of this simple device the process of vapor distillation becomes a particular type of osmotic diffusion, viz. osmotic diffusion across a vacuum. We can consequently arrive at many of the factors governing the magnitude and direction of osmotic flow, and the magnitude of the osmotic pressure, by considering the factors which determine the relative values of the vapor pressures of the pure solvent and solution respectively. This is done in the latter part of the paper.

Mr. W. R. Bousfield then gave his paper entitled

"Osmotic Pressure in Relation to the Constitution of Water and the Hydrates of the Solutes."

This paper deals with the subject of osmotic pressure from the standpoint of the ternary constitution of water, which alone can explain the curious fact that for a very dilute solution of sugar the osmotic pressure at 0 deg. C. is greater than that at 5 deg. The vapor pressure theory is shown to be sufficient to explain all the phenomena without postulating osmotic pressure as an "expansive force." It is shown that the osmotic relationships can be deduced with great accuracy on the simple hypothesis that the steam molecules in water behave as a perfect gas in the interstices of the solution. The conclusion is that it is not the solute but the interstitial vapor of the solvent which behaves as a gas, and that it is not the activity of the solute but that of the solvent vapor which is responsible for the phenomena.

He then proceeded to discuss the views put forward by Professor Porter. A theory which left out of account, comparatively speaking, the activity of the solvent, seemed to him the wrong way of looking at things. Criticizing the contention that the diffusion, say, of sugar introduced into a solution indicates an expansive force, he maintained that osmosis might be equally regarded as due to the water expanding in the opposite direction. If the pressure of sugar arose from its thermal motion, why at the surface was it the vapor of the water which escaped and not the sugar? What really obeyed the gas law in solution was not the solute but the occluded vapor comprised in the solution. Figures calculated from his theory agreed with those observed more closely than those deduced from Professor Porter's theory.

Dr. S. A. Shorter held that the "gas law" of osmotic pressure, though simple from an algebraical point of view, was very complex from the point of view of the kinetic theory, so that the law formed a very unsatisfactory basis for the theory of the ideal dilute solution. The correct basis for the theory was Henry's law, which stated that the partial pressure of the solute was proportional to its concentration, and which was readily established on theoretical grounds—simply following from the obvious consideration that the field of force, in which each solute molecule moved, was not affected by the addition of further solute molecules. The constant of proportionality depended upon the nature of the intermolecular forces, being vastly greater in the case of, say, solutions of benzene in water than in the case of, say, solutions of methyl alcohol in water. From Henry's law we could readily establish Raoult's law and the "gas law" of osmotic pressure, neither of which could be deduced from simple theoretical considerations, and neither of which contained any reference to intermolecular forces. This latter point constituted a grave defect in the ordinary osmotic theory. Since it ignored intermolecular forces in dilute solutions, it led many investigators to ignore them in concentrated solutions, and to adopt the totally unjustifiable procedure of postulating certain ideal properties of a concentrated solution, and then ascribing departures from this ideal to chemical action (dissociation, association, or solvation). Now, it was evident, from a consideration of the theoretical basis of Henry's law, that intermolecular forces must control the mode of variation with concentration of the partial pressure of the solute in a concentrated solution. The same must be true of the partial pressure of the solvent, and of the osmotic pressure, since they were both related thermo-dynamically to the partial pressure of the solute. Theories of the chemical structure of concentrated solutions, based on the concept of the ideal concentrated solution, were fundamentally unsound.

The most necessary step toward a fuller knowledge of the processes operative in solutions was the further development of the kinetic theory of solution. The points to be explained first of all were not the comparatively minute deviations from some imaginary ideal behavior exhibited by certain solutions, but such broad questions as the existence of different types of partial vapor pressure curves, the total or partial miscibility of liquids, the existence of a critical temperature with respect to miscibility, etc.

The Earl of Berkeley, as an illustration of one of the difficulties in the internal vapor pressure theory, referred to the diffusion which would take place if a layer of potassium bichromate were placed at the bottom of a column of concentrated sulphuric acid, the vapor pressure of which was practically nil. He inquired as to the accuracy of the latent-heat method of measuring osmotic pressure.

Prof. J. C. Philip stated difficulties he felt with regard to Dr. Tinker's explanation of the selective action of the membrane. As far as size was concerned, a sugar molecule could pass through the pores of the membrane. If the pores had the power of absorbing water, why should not that water absorbed itself take up the sugar molecules, making the membrane "leak"? Recent experimental work on hydration led to somewhat higher figures for the average number of water molecules associated with sugar in solution than the numbers assumed by Mr. Bousfield, namely, from 11 in dilute down to about 7 in strong solutions. Prof. Porter had obtained similarly higher figures.

Dr. G. Senter, while agreeing largely with Professor Porter's theory, criticized his views on hydration, and in particular the assumption that the uncertainty in the value of b in Hirt's equation was to be accounted for by hydration.

Mr. W. C. Dampier Whetham thought that the relations between osmotic phenomena and vapor pressure and freezing-point which Mr. Bousfield had deduced amounted in effect merely to a confirmation of thermodynamic relations. To get a satisfactory theory of the mechanism of osmotic pressure it was necessary to begin with first principles, and he thought the gas theory the only one which enabled this to be done.

Prof. A. Findlay, in a written communication, emphasized the importance of distinguishing between the equilibrium pressure and the process by which this was produced. The process of osmosis and the rôle of the membrane had little reference to the main problem of the value of the equilibrium pressure and its relation to the constitution of the solution. He combated the view that osmotic pressure (a term he thought misleading) was to be identified with the expansive force that brought about diffusion, and he could not accept Professor Porter's kinetic treatment of the problem. The weakness in this arose from the use of the equation $P(v-b) = RT$ in attributing deviations from it to hydration. The connection between heat of dilution and osmotic pressure seemed a fruitful direction for investigation. He favored the view, mooted by Tammann, that osmotic pressure was caused by the inner compression of the solvent in solution. Some recent calculations by Horiiba lent support to this theory.

Mr. J. R. Partington, in a written communication, showed how it followed from molecular theory that although the physical state of the dissolved molecules might not be comparable with that of the gaseous molecules, yet they could behave with respect to bombardment as if they were in the state of a gas. The question as to whether the osmotic pressure was "caused" by solute or solvent appeared to him to be largely meaningless.

Mr. F. S. Spiers (communicated) considered that a satisfactory conception of osmotic pressure was arrived at if one regarded it as the *diminution* in the kinetic molecular energy of the solvent due to association with the solute. This view not only took account of both solvent and solute, but it also gave a simple picture of the process of osmosis, and suggested at once the connection between osmotic pressure and vapor pressure.

Prof. Alfred W. Porter replied at this stage to some of the criticisms that had been made. The solute molecules contribute nothing to vapor pressure, simply because when they get near the surface they are drawn downward by the solvent and never succeed in escaping. The answer to Dr. Philip was, he thought, that the canals in the membrane must be narrow compared with the range of molecular action, although not necessarily compared with molecular dimensions. In answer to Lord Berkeley, the method of using latent heat of dilution to determine osmotic pressures gave very considerable accuracy.

Prof. T. S. Moore considered that the modification of the gas theory required to explain the action of a solute in solution was so fundamental that it ceased to be a gas theory. The internal pressure of a solution being exceedingly high, it was impossible to suppose that the pressure exercised by the solute molecules could be independent of the solvent molecules and of the forces exerted by the solute on the solvent, which were the assumptions made by Professor Porter. A molecular theory of osmotic pressure must form part of a general molecular theory of solution.

Sir Oliver Lodge, in bringing the discussion to a close, pointed out that in a liquid they had to deal with an internal pressure, due to the mutual attraction of the molecules, of great magnitude. The source of osmotic pressure was probably to be looked for in this internal pressure.

Norwegian Company to Manufacture Peat Fuel.—A company is in process of formation in Norway for making fuel from peat by the Rosendahl method. The capital of the company is to be between 600,000 and 1,000,000 crowns (between \$160,800 and \$268,000). The raw material for the new industry will be chiefly peat from the extensive Norwegian moors, but any organic material may be used which is sufficiently abundant in the neighborhood of the factory, *e. g.*, wood waste. The product is said greatly to resemble English coal. Preliminary experiments have been conducted not only in the laboratory but also under factory conditions on a small scale, and the product is stated to have been satisfactorily tested in Christiania households.

University of Wisconsin Summer Session.—The nineteenth annual summer session of the College of Engineering of the University of Wisconsin will be held at Madison during the six weeks period beginning June 25, 1917. Special courses will be given in Chemistry, electrical, steam and hydraulic engineering, gas engines, machine design, mechanical drawing, mechanics, shop work, and surveying. All courses given in the University summer session are open to engineering students. Special courses have been arranged for engineering, manual arts, and vocational teachers. For information, address F. E. Turneure, Dean, Madison, Wis.

Fellowship in Refractories.—The Refractories Manufacturers' Association, whose headquarters are at 220 South Michigan Avenue, Chicago, Ill., has endowed an industrial fellowship at the Mellon Institute in Pittsburgh.

Annual Meeting of Iron and Steel Institute in London

The annual meeting of the British Iron and Steel Institute was held in London, May 3 and May 4, 1917. An attractive program of technical papers was presented and several interesting announcements were made.

The new president of the Institute is SIR WILLIAM BEARDMORE. Professor HENRY M. HOWE (U. S. A.) was elected an honorary vice-president.

The Bessemer Medal for 1917 was presented to Mr. Andrew Lamberton, in recognition of his work in mechanical engineering appliances in the iron and steel industry.

Following is a list of the papers read at the meeting:

Properties of the Refractory Materials Used in the Iron and Steel Industry. By Cosmo Johns (Sheffield).

The Determination of the Line *SE* in the Iron-Carbon Diagram by Etching Sections at High Temperature *in Vacuo*. By Professor Tschischewsky and N. Schulgin (Tomsk, Russia).

The Influence of Surface Tension Upon the Properties of Metals, Especially of Iron and Steel. By F. C. Thompson (Sheffield).

Cementation by Gas Under Pressure. By F. C. Langberg (Cambridge, Mass.).

The Penetration of the Hardening Effect in Chromium and Copper Steels. By L. Grenet (Firminy).

The Case-Hardening of Iron by Boron. By Professor Tschischewsky.

Steel Ingot Defects. By J. N. Kilby (Sheffield).

Notes on Some Quenching Experiments. By L. H. Fry (Burnham, Pa.).

Origin and Development of the Railway Rail in England and America. By G. P. Raidabough (Sparrow's Point, Md.).

REFRACTORY MATERIALS USED IN THE IRON AND STEEL INDUSTRY

The author of this paper, COSMO JOHNS, took up a discussion of the sources and properties of the various refractory materials used by the iron and steel industry in England. He said that the art has been so long in front of the science of the refractory industry, that the most urgent need at present is for an expression, in terms of scientific precision, of the most successful practice in manufacturing the refractory product and of the physico-chemical changes which take place when they are used.

"Tenacity and compressive strength at ordinary temperatures are valuable only in so far as they permit the refractory products to be transported and enable them to withstand the structural stresses to which they are exposed when used. This is not difficult to attain. It is when the material is exposed to high temperatures that the value of these properties becomes most important. The abrasion caused by the movement of solid substances while in contact with their heated surfaces is important, while the erosion caused by the passage of dust-laden gases at high velocities become serious in time. Little or nothing is known of the conditions that favor or retard abrasion and erosion. High tenacity, which in most cases would mean that of the bonding or of the most fusible constituents, is most probably the desired property. It is the surface exposed to the highest temperature which suffers, for it is the one that is in contact with the moving solids, liquids, or gases. Compressive strength is rarely a cause of failure, for the bulk of the refractory material is at a lower temperature than the face and therefore less affected. There is, however, urgent need for accurate determination of the two properties under discussion at wide ranges of temperature for the more important materials under both oxidizing and reducing conditions.

"Not less important than resistance to high temperature with concurrent abrasion and erosion is resistance to the

corrosion caused by slags gases. The effect of acid slags on basic refractories and of basic slags on acid refractories are familiar, while a most striking example might be indicated on the marked corrosion of the silica bricks in the gas ports and uptakes in open-hearth furnaces, due to the alternating passage of oxidizing and reducing gases with the resulting formation of fusible silicates. A factor conducive to rapid corrosion in the last case is the absence of large particles of silica in the bricks employed and the presence of excessive pore spaces. Here again little has been published and few observations recorded. The effect of the alkalis found in certain coals on the refractories used in coke-oven construction is serious, and here too little is known as to the real nature of the destructive influences at work.

"In the case of coke ovens the retention of gas-tight partitions is absolutely necessary, and this involves the use of a refractory material which does not undergo appreciable volume changes. This means that a mixture of substances with volume changes of opposite sign are employed, viz., clay and silica. But while the contraction of the burnt clay is fairly regular with increased temperatures, quartz, which is the form of silica found associated with it in nature, has an inversion point at which it becomes trysidite. In the presence of certain compounds this inversion takes place at a temperature lower than that at which coking is carried on. In their absence the inversion is retarded and does not take place until a temperature higher than that usual in coking practice is attained.

"Owing to the complex nature of most of the materials used in practice, their properties are not those of the simple minerals of which they are composed, but the resultant of variations which are sometimes of opposite sign and are always varying at different rates. The relative size of the grains employed, the extent of the surface exposed by the more resistant constituents to the others used as bond or matrix, are most important factors in contributing to the ability of the material to perform useful service. Another point of some importance is the influence of mass in promoting or retarding inversions. Some of these inversions take place almost instantly once the critical temperature has been reached, but with others marked hysteresis occurs. Porosity must always occur when the refractory material is composed of more than one constituent, and where their chief volume changes are dissimilar or occur at different temperatures. Little is known of the effect of porosity on the properties of refractory materials. That the pores encourage the deposition of extraneous substances in the interior of the bricks, and that they render the structure permeable to gases, is of course obvious.

"The stresses caused by temperature changes are due to the volume changes which take place during heating. If the refractory material happens to be a good conductor of heat these are not serious, unless one face is rapidly heated and the distortion produced exceeds the tenacity of the material. The remedy available is to avoid rapid temperature changes, and whenever possible to raise the temperature of the material during the burning stage of manufacture well above that at which the inversion to the principal volume change should take place, and to hold it at that temperature long enough for the inversion to be completed. The 'spalling' of magnesite bricks which sometimes occurs has been thus explained, and, it is certain that the excessive expansion of silica bricks would be avoided if the manufacturer could ensure the completion of the quartz-trydimite inversion during burning. Despite the considerable advances in our knowledge of the inversion of silica made recently, their bearing on the problems that face the manufacturer are not yet sufficiently clear.

"The first step—and in all probability the one easiest to take—would be to prepare specifications for the most important refractory products expressed in terms capable of precise measurement or description, basing the specification on the best current practice. This would only be following the excellent example of the gas industry. But specifications at their best only serve to stereotype the best current practice of their day. These specifications should be the starting point of systematic research which should cover, not only the problems that occur during manufacture, but the occurrence in nature and characteristics of the raw materials. Their concentration and purification, proximate and ultimate analysis, mineralogical description and thermal analysis are all points on which additions to our present knowledge would be of great value. But the refractory materials are so complex, and the problems involved are so difficult of direct attack, that any contributions to our knowledge of the properties of the pure minerals, or of the impure aggregates which are used in practice, would be welcomed, even if their immediate application did not happen to be possible."

Leads for Electric Furnaces

By Prof. Arvid Lindström

(Translated from Teknisk Tidskrift, March 7, 1917)

With the increasing size of arc or resistance furnaces the difficulties of conveying the current from the transformer to the furnace have become more pronounced. With electrode potentials of as low as 50 and 100 volts, the current necessarily will be very high, requiring in turn conductors of a large cross-section and under such conditions two difficulties are met with.

One is due to the "skin effect" or the tendency of the alternating current to concentrate in the portion of the conductor nearest the surface; this obviously results in a greater energy loss than would be desirable with a given weight of copper, or a greater weight of copper would be required than would be justified for a certain loss.

The other difficulty is due to the self-inductance of the conductor loop which connects the transformer with the furnace, resulting in a low power factor of this loop, and consequently of the entire installation, with its accompanying disadvantages and additional expenses of different kinds. There are, of course, several types of furnaces (nitrogen furnaces) where a large self-inductance is desired for stabilizing purposes, especially during the starting period, but not even with these does it seem that an inductance inherent and inseparable from the system is desirable.

It is from the above two points of view that the problem of furnace conductors will be dealt with in the following article, and an endeavor will be made to show how the best results may be accomplished when designing the leads, and also how the results may be investigated by tests. As an illustration a known furnace installation will be taken for an example.

I—The Effective Resistance of Large Conductors and Their Proper Arrangement

It has been known for many years that, especially with round conductors, the resistance with alternating current is greater than with direct current, due to the phenomenon known as "skin effect." For round conductors Hospitalier has calculated a table for the ratio $R_c/R_o = X$ = effective resistance with alternating current / resistance with direct current as function of f and d , where f is the frequency, d is the diameter of the conductor in cm. (1 centimeter = 0.3937 inch).

From this table the following values only will be given:

fd	X
720	1.32
1280	1.68
2000	2.04
2880	2.39
5120	3.10
8000	3.79

The furnace chosen for the example has a capacity of 900 kilovolt-amperes at the lowest potential of 50 volts, so that the highest current is consequently 18,000 amperes. The frequency is 50. The conductors consist partly of four bars 200 x 15 mm., spaced comparatively close and connected in parallel. This corresponds to a cross-section of 120 sq. cm., or a round solid conductor with

Diameter $d = 12.4$ cm.
 $d = 154$
 $fd = 7700$
and therefore $X = 3.7$.

With less than one-third of the utilized copper weight it would have been possible to maintain the same resistance and loss if the above skin effect could be avoided. (It may be noted that for 25 cycles X would have been $\sqrt{2}$ times less, thus $X = 2.6$.) It may now be objected that the conductor did not consist of one single solid round conductor. This is true, but it must



FIGS. 1 TO 3—CONDUCTOR ARRANGEMENT

be remembered that if the conductor is split as, for example, in Figs. 1 and 2, no gain is obtained in this respect if the spaces between the laminations do not take away any appreciable part of the section, and evidently also under the consideration that the laminations are parallel connected at the ends and not transposed along their length. With the exception of at the ends, the current travels nowhere in any other direction than that of the conductor, or, in other words, the current has no component in any other direction, and the current distribution is therefore not at all affected by the splitting up of the conductor.

If instead of being round the conductor had a rectangular or nearly square cross-section, as in Figs. 3 and 4, but of the same area, the conditions would nevertheless not have been much improved. This is readily conceived by comparing the contours of the square and the corresponding circle. The current distribution in the cross-section is a matter which principally depends on the distance of the different current elements from the center.

In our case the four bars are arranged about as shown in Fig. 5. The bars are spaced wider apart and



FIGS. 4 TO 6—CONDUCTOR ARRANGEMENT

the average specific conductivity is consequently less, but not to such an extent that any appreciable decrease of X is obtained. At the same time as this specific conductivity has decreased, the linear dimensions of the cross-section have increased, and without introducing a too great error it may be assumed that the resistance in this case is approximately three times as great for the 50-cycle alternating current as for direct current, or

$X = 3.$

Now the question arises: How shall the conductors be arranged in order that a considerably better result may be obtained? The first thing which suggests itself is the use of only one bar, not too thick but much wider, for example 800 x 15 mm., 600 x 200 mm., or 480 x 25 mm.—in any case a bar whose width is 20 to 50 times its thickness, and we will in the following see what value X will get in such a case.

Steinmetz has calculated the current distribution in flat conductors in air. Starting out from the same assumptions, the writer has also calculated the effective resistance of similar conductors. The calculations are not given here, but it may be stated that the results are fully analogous to those obtained for conductors in armature slots.

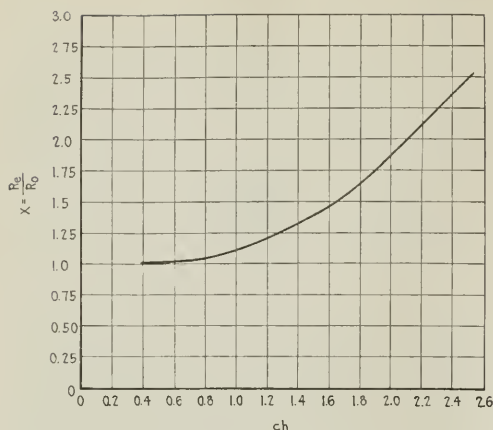


FIG. 6A—DIAGRAM FOR FINDING X

If h = half the thickness of the conductor in cm.,

$$c = 2\pi\sqrt{\mu\lambda f}$$

where

μ = permeability of the material,

λ = specific conductivity,

f = frequency,

then X may be obtained directly from the curve in Fig. 6a. This is on the assumption that the width of the conductor is infinite in comparison to the thickness, an assumption which, while not of course strictly true, may be considered to approximately apply to our case. When

$$\lambda = \frac{1}{2000} \text{ for copper } (c = 0.02)$$

$$\mu = 1 \text{ for copper}$$

$$f = 50$$

$$c = 1$$

Then

is now the thickness $= 2h = 1.5, 2.0, 2.5$ cm.

then $ch = 0.75, 1.0, 1.25$

and according to Fig. 6a $X = 1.03, 1.09, 1.21$.

In all three cases, but especially in the first and second, a considerable reduction in the loss (about one-third) has been accomplished with the same weight of copper. For example, we could use a conductor 500×8 mm., or only one-third of the originally assumed weight, and obtain then

$$X = 1$$

that is, the same loss as that now prevailing. Two-

thirds of the installed copper could therefore be saved, and the temperature would certainly not be materially higher for this conductor than that of the four bars installed.

If, now, these four bars, Fig. 5, are moved together as shown in Fig. 6, and we treat the 200×60 -mm. conductor thus obtained as one of considerable width as compared to its

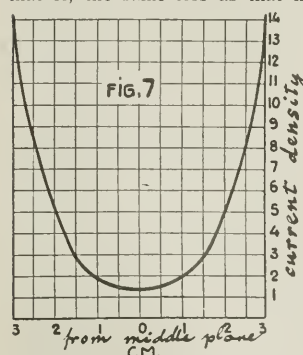


FIG. 7—RESULTS FOR CONDUCTOR OF 60-MM. THICKNESS

thickness, we get $X = 3$. This result may not be considered as exactly correct, but it points in the right direction and checks with that previously obtained.

The effective value of the current density at the distance X from the middle plane of the bar may be calculated from the following equation:

$$i = A\sqrt{2}\sqrt{\cos h2cX + \cos 2cX}$$

where A is a constant and c has the previous meaning. The result for the conductor with the 60-mm. thickness is given in Fig. 7. The current density nearest the surface is not less than ten times as great as in the center. It is evident that the density varies in the other direction also, so that a concentration will take place both near the upper and lower edges, a condition which is caused by the fact that the width of the conductor is not infinite. In Fig. 5, where an approximate relative view of the cross-section of the actual conductors is given, an attempt has been made to indicate the density in the different parts of the section by shading.

A measurement of the temperature of the bars showed a rise of 32 deg. C. for the two middle bars and 51 deg. C. for the two outside ones; with a current of approximately 14,000 amperes. Considering the poorer radiation of the two former, it is evident that the current in the latter was considerably greater.

Even with the above suggested arrangement with one single bar 500×8 mm., a concentration of the current towards the edges must take place, so that even in this case a somewhat increased resistance will result. To avoid this, the conductor may be shaped as a pipe or tube, and if its diameter is fairly large as compared to the thickness of the walls, the calculation used for a bar of infinite width may be applied without appreciable error. With a thickness of 8 mm. the outside diameter

of the tube would therefore be $\frac{500}{\pi} + 8 = 168$ mm.,

this being based on the assumed area of 4000 sq. mm., which is one-third of that installed (12,000 sq. mm.). With this area, on the other hand, the tube could be built with a thickness of 15 mm. and an outside diameter

of $\frac{800}{\pi} + 15 = 270$ mm. In that case

$$X = 1.03$$

and consequently the resistance approximately one-third of the present.

Another method would be to arrange the four 200×15 -mm. bars as shown in Fig. 8, an arrangement which, however, from a practical point of view, appears to be less advisable.



FIG. 8

Instead of an entirely closed tube, it can be separated into two halves as in Fig. 9, but in the former case it is possible to provide for a very effective cooling inside the pipe.

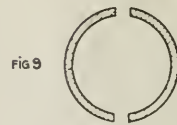


FIG. 9

FIGS. 8 AND 9—OTHER ARRANGEMENTS

The conductors for the first furnaces of this plant, which were installed a few years ago, were made of closed tubing, but for the more recent units they consist of four parallel connected bars, with the result explained above.

II—The Self-inductance in Electric Furnace Leads and Means for Reducing the Same

The connections between the transformer and the furnaces are made as shown in Fig. 10. The loop in

which the self-induction takes place is a, b, c, d, e, a , and this should obviously be made as small as practical conditions will permit, consideration, of course, also being given to copper weight and energy loss. The distances bc and de are each, as a rule, approximately 3 m. at least. The question then arises, how can the self-induction in such a small loop, consisting of only one turn, reach such a value as to cause undue difficulties? The inductance L in itself is not large, but the voltage drop caused thereby,

$$E_s = 2\pi fLI.$$

This is naturally due to the large value of I , and on the other hand the value seems particularly large when compared to the voltage of the furnace (50 to 100 volts).

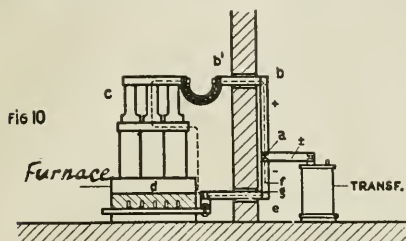


FIG. 10—CONNECTION BETWEEN TRANSFORMER AND FURNACE

By means of the following formulæ, the self inductance of a round conductor forming a circular loop, Fig. 11, can be calculated:

$$L = 4\pi R \left(0.58 + \log_e \frac{R}{r} - \frac{2r}{R} \right) 10^{-9} \text{ henry}$$

where

R = the radius of the loop in cm.

r = the radius of the conductor in cm.

If, in Fig. 10,

$$bc = de = l = 300 \text{ cm.}$$

$$cd = be = l_1 = 400 \text{ cm.}$$

and if the rectangular arrangement is assumed to be changed to a circular one with the same circumference, its radius will be

$$R = \frac{2 \times 300 + 2 \times 400}{2\pi} = 220 \text{ cm.}$$

If we also assume that the leads are so heavy and so constructed that the radius of an equivalent tubular conductor is

$$r = 12 \text{ cm.}$$

then the self-inductance will be

$$L = 0.934 \times 10^{-9} \text{ henry.}$$

With a current of 18,000 amperes we get

$$E_s = 53 \text{ volts.}$$

For a rectangular loop it is, however, possible approximately to deduce the self-inductance directly as follows: If the self-inductance for the two opposite parallel sides l are calculated in the usual manner for themselves and similar for the two sides l_1 , it is evident that the total inductance of the loop will be approximately equal to the sum of the two, and thus

$$L = 4 \left(1 \times \log_e \frac{l}{r} + l_1 \log_e \frac{l}{r} \right) 10^{-9} \text{ henry}$$

$$= 0.934 \times 10^{-9}$$

or (accidentally) exactly the same value as before. This value is, however, too high on account of the fact that the entire side cd , which comprises the electrodes with their holders and the furnace itself, has a considerably greater cross-section (and consequently greater r) than the rest of the circuit. Taking this into con-

sideration and calling the radius (in the equivalent circle) for this side for r_1 , then we get

$$L = 2 \left(2l \log_e \frac{l}{r} + l_1 \log_e \frac{l}{r} + l_1 \log_e \frac{l}{r_1} \right) 10^{-9} \text{ henry.}$$

Assuming

$$r_1 = 40 \text{ cm.}$$

we get

$$L = 0.836 \times 10^{-9} \text{ henry,}$$

and

$$E_s = 47 \text{ volts.}$$

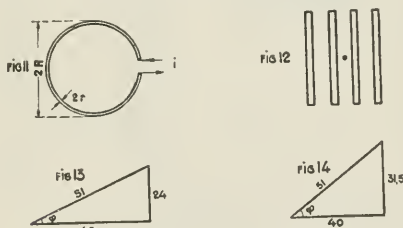
That part of the inductance which is caused by the magnetic field within the conductor itself has been neglected, but when, as previously stated, the current to a greater extent is concentrated near the surface, the error is not appreciable. On the other hand, it may be suspected that the value is too great on account of the fact that the side be partly consist of cables which are spread out considerably, in which case r , of course, is greater than assumed even for this part of the loop. Furthermore, these cables sag considerably, which makes the area of the loop less. On account of the many irregularities which the loop presents, it is evident that in general only an approximate result can be expected, and in this particular case possibly a somewhat too large value for the inductance.

III—Measurement of Resistance and Inductance in Furnace Leads

To measure exactly the effective resistance of the furnace leads in our case seems hardly possible. An endeavor to do this was made and will be explained in connection with the inductance measurements. The matter is, however, not of such a great importance, partly because the losses are not appreciable and partly because of the fact that the conductors should be so arranged as to reduce the skin-effect losses to a minimum.

It is customary to measure the inductance by means of voltmeters, ammeters and wattmeters connected on the primary side of the transformer, in which case the phase displacement on this side may be determined. Knowing the characteristics of the transformer it is then possible to calculate the phase displacement as well as the energy and wattless voltage components in the leads. This requires very accurate and often high-potential instruments with current and potential transformers. On the other hand, the inductance in the furnace leads will be combined with the leakage inductance of the transformer, and the latter must therefore be known in order to determine the former.

The writer has therefore—for both reasons—used another more simple and direct method, consisting in measuring the inductive voltage component of the furnace leads directly with a voltmeter. A pressure wire was placed between the loop conductors, as shown by the dotted line in Fig. 10 as well as in Fig. 12, where the dot represents the relative position of the wire with



FIGS. 11 TO 14—ARRANGEMENTS OF MEASUREMENTS AND VECTOR DIAGRAMS

respect to the copper bars. The potential between the ends *f* and *g* of this wire was determined by a hot-wire voltmeter, which is the only type of meter which can be used within a reasonable distance from the leads on account of their strong magnetic field. This circumstance is also the principal reason for the difficulty to make measurements, as explained above, on the primary side of the transformer, because even there it becomes difficult to place the sensitive instruments so far away as not to be affected by the magnetic fields. Even if the hot-wire instrument is not a precision instrument, it is at least unaffected by these fields and the directness of the method does not involve any appreciable precision.

With the furnace in question, the following values were obtained:

Current in furnace leads = 13,700 amperes.

Voltage at transformer terminals = 51 volts.

Voltage between *f* and *g* = 24 volts.

The current was measured on the primary side of the transformer, also with a hot-wire instrument, and the transformer therefore had to serve as a current transformer in addition.

The voltage triangle is as shown in Fig. 13, so that

$$\cos \phi = \frac{40}{51} = 0.88$$

If the current were 18,000 amperes and the total pressure of 51 volts maintained, the voltage *fg* would be

$$\frac{18,000}{13,700} \times 24 = 31.5 \text{ volts,}$$

and the voltage triangle as in Fig. 14, or

$$\cos \phi = \frac{40}{51} = 0.785$$

which value would apply for our circuit under full load.

One weakness of this measuring method is due to the difficulty in placing the pressure wire just right, in that it cannot, of course, pass centrally through the electrodes and the furnace itself. The inductance voltage will therefore be a little too low, but in any case it may be assumed that measurements with different arrangements of the leads are sufficiently accurate for comparisons.

An endeavor was also made to measure the resistance component of the pressure drop for part of the circuit. This was done by connecting one terminal of the voltmeter to one of the middle bars at *a* (Fig. 10) and the other terminal to an isolated wire, which was inserted between points *a* and *b'* between the bars as before. The other end of this wire was connected to the same bar at *b'*. The potential between the two points of the bar was measured to be approximately 1 volt at a current of 14,000 amperes. In order that this shall repre-

sent the real resistance drop between points *a* and *b'*, it is evident that the sum of all the induced e.m.f.'s in the external as well as the internal voltmeter circuit must equal zero. With the strong magnetic field which is caused both by this particular part of the circuit as well as the other parts of the loop, it is hardly possible that this condition can be exactly met, and as its effect would greatly influence the result, it follows that its exactness would be very doubtful, and consequently the value of this method with respect to measuring the resistance comparatively small.

As previously mentioned, this installation also contained some older furnaces, the leads of which consisted of copper tubing instead of bars. The leads were furthermore divided in two branches (tubes) carried some distance from each other, as shown in Fig. 15. A pressure wire was placed in one of the parallel pipes and the following results obtained:

Current in furnace leads = 18,400 amperes.

Potential at transformer terminals = 50 volts.

Potential between *f* and *g* (Fig. 10) = 22 volts.

The voltage triangle at 18,000 amperes is therefore as in Fig. 16, and

$$\cos \phi = \frac{45}{50} = 0.9$$

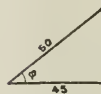


FIG. 16—VECTOR DIAGRAM

As $\cos \phi$ in the previous case for the same current was 0.785, it is seen that the older method gives considerably better results as far as the inductance is concerned. This depends on the fact that tubes are used instead of the laminated bars, but principally because the lead for each pole is divided in two separate tubes. In these tubes, as follows from the above, the increase in the resistance and the additional losses are considerably less than with laminated bars.

IV—Summary

In those parts of the circuit between the transformer and the furnace where the two leads come near together (for example, between the terminals of the transformer and point *a* in Fig. 10), there is no difficulty in keeping the inductance or the effective resistance within reasonable limits; for example, by suitably transposing the positive and negative bars. In such cases where the common distance is relatively great, considerable can be gained by making the leads of two concentric tubes. The inductance as well as the increase in the resistance will thus be a minimum.

In those parts of the circuit, on the other hand, where each pole has a separate path, the use of a single group of laminated bars for each lead would, in general, seem unsuitable, and this especially where large cross-sections are involved. As near as possible to the place where the leads separate, each conductor should be divided into two groups, placed sufficiently far apart with respect to the length. With not an altogether too great current, each of these groups may consist of a single bar whose thickness should not exceed 15 to 20 mm. If the current is great, so that for practical reasons a total thickness of the bars for each group of more than 20 mm. would have to be used, tubes should preferably be used instead of bars. Otherwise the arrangements should be as stated above—that is, two tubes for each pole should be used, placed a suitable distance from each other and with a thickness of the walls from 15 to 20 mm. In general, a greater diameter of the tube (and consequently a less thickness of the walls) as well as a greater distance between the groups will give a better result in regard to the inductance as well as to the increased resistance.

It has been the aim to show a method, even if only

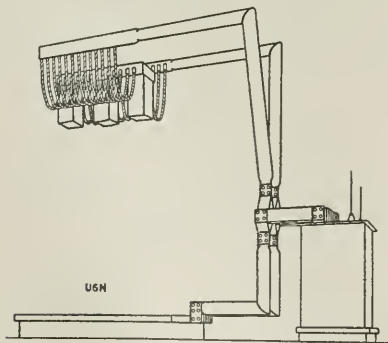


FIG. 15—OTHER ARRANGEMENT OF LEADS

approximate, to measure directly the self-inductance and phase displacement of the low-tension furnace leads of a completed installation by means of simple apparatus.

Impurities in Electrolytic Copper Refining

By Lawrence Addicks

Electrolytic refining gives a triple separation of the various impurities in a blister copper anode, distributed in the anode slimes, the electrolyte and the cathode. The chief object of the process is, of course, to make a pure cathode, and secondarily to keep impurities from mounting too high in the electrolyte, in order to keep the cost of purifying the electrolyte within reasonable limits. The ideal process would, therefore, send all of the impurities into the anode slimes, which would then be worked up into various by-products, and the electrolyte would stay of a constant composition. Practically a considerable proportion of the impurities dissolve in the acid sulphate electrolyte, and steps have to be taken for systematic purification of the solution.

Both the problem and the means of dealing with it have greatly changed in the last twenty years. Two decades ago, when electrolytic refining was in its infancy, there were large quantities of black copper to be treated, and many of the smelters were producing pig high in arsenic. An idea of this situation may be gained from some representative analyses of pig copper of that period, given in Table I:

TABLE I—SOME PIG COPPERS ELECTROLYTICALLY REFINED IN 1901

Brand	Arsenic	Antimony	Iron	Sulphur	Lead	Copper
Argentina	0.46	0.40	0.03	0.15		96.5
Chicago	0.30	0.19	0.22		1.72	96.0
Germany	2.92	0.17	0.01	0.07		95.0
Philadelphia	0.86	0.08	None	Trace		96.2

This whole situation was changed when the strongly reducing action of the black copper furnace and the practically neutral atmosphere of the copper-producing reverberatory were supplanted by the strongly oxidizing Bessemer converter, and the widespread use of sulphur as a carrying agent for copper brought nearly the whole production through a process which efficiently removed most of the objectionable impurities.

On the other hand, some imported copper pig is of less than standard purity, and there is a steadily increasing production of secondary copper from plants treating junk by the old processes, and they often produce very foul pig. Some representative analyses of these various classes are given in Tables II, III, IV:

TABLE II—ANALYSES OF SOME EXAMPLES OF SECONDARY PIG

Brand	Arsenic	Antimony	Sulphur	Iron	Nickel	Lead	Copper
A	0.03		0.94	0.92	0.35	5.49	85.0
B	0.03	0.05	1.02	0.36	0.32	2.68	84.8
C	0.05	0.19		0.93	0.47	5.25	82.4
D	0.05	2.25	Trace	Trace	None	12.79	82.6
E	0.05	0.41		5.65	1.38	2.02	
F	0.05	2.63	0.75	5.53	0.33	2.36	84.9

TABLE III—ANALYSES OF SOME FOREIGN PIG COPPER

Country	Arsenic	Antimony	Sulphur	Iron	Nickel	Lead	Copper
Chili	0.10	0.01	0.74	0.99	0.22	0.03	97.4
Japan	0.18	0.12	0.39	0.03	0.06	0.83	97.6
Peru	0.13	0.20		0.03	Trace		
Spain	0.11		0.69	1.03	0.02	0.13	97.7

TABLE IV—ANALYSES OF NORMAL BLISTER COPPER

Country	Arsenic	Antimony	Sulphur	Iron	Nickel	Lead	Copper
Australia	0.001	0.011	0.224	0.029	0.047	0.003	98.30
Canada	0.057	0.045	0.090	0.050	0.111	0.002	98.80
Mexico	0.017		0.260		0.040		
South America	0.007		0.188	0.037	0.044	0.028	99.20
United States	0.008	0.006	0.045	0.034	0.037	0.007	99.30

We have, therefore, the general problems of keeping the impurities out of the refined copper and of working up such of the impurities from the anode slimes and the electrolyte as may show a commercial profit.

The early refineries had much trouble with even the first leg of this proposition, and the uncertainty as to the chemical purity of electrolytic copper produced in the early days had much to do with the premium established in favor of Lake Copper. Arsenic was the chief enemy, and its elimination from the electrolyte became the main metallurgical problem of the plant.

This situation brought about the development of a by-product bluestone plant, fed by systematic withdrawals from the electrolyte, the final mother liquors being precipitated upon iron and discarded.

Then the flood of incoming arsenic abated, and in some cases nickel became the major impurity, bringing about the development of the by-product nickel sulphate plant, the mother liquors being returned to the electrolyte.

In general, one of these two methods of control of the composition of the electrolyte have been used, and they will be examined more or less in detail later on.

The anode slimes were at first cupelled with lead, and only the silver and gold recovered, these being parted by sulphuric acid. Later, lead practice was discarded, except by those plants operated in conjunction with a lead refinery, and much work has been done upon the recovery of selenium, tellurium, platinum, palladium, arsenic, antimony, bismuth, etc. A quite complicated pyro-metallurgy, followed by electrolytic parting, has been developed, and much research devoted to the possibilities of a full wet process.

A discussion of the general question of impurities, therefore, falls under six main headings, namely: (A) sources, (B) exits, (C) distribution, (D) chemical requirements of refined copper, (E) recovery of soluble impurities from the electrolyte, and (F) recovery of insoluble impurities from the anode slimes.

A—Sources

Apart from the entering pig copper there are as many sources of impurities as there are supplies entering the process. While, of course, many of these sources are quite negligible, some are of sufficient magnitude to be worthy of consideration. Among these are fuel, fluxes and acids.

Fuel enters the process at various stages, but the only place where it is of account in this discussion is in the melting of cathodes. Here the various products of combustion and particularly the sulphur have to be reckoned with, as sulphur is one of the principal impurities in refined copper. The discussion of this question falls more normally under the head of chemical impurities in refined copper.

Fluxes include, by a somewhat liberal definition of the word, the materials of which the furnaces are made insofar as they enter the metallurgical slags, the true fluxes, such as limestone and pyrites cinder added in the retreatment of these slags, the charcoal or other carbonaceous covering used to protect molten copper from undue oxidation, bone ash or similar material used to "butter" the molds, and soda nitre and soda ash used as fluxes chiefly in the treatment of the anode

slimes, and the antimonial lead with which the tanks are lined.

Under acids we have sulphuric, nitric and hydrochloric, the last sometimes as sodium chloride. The sulphuric acid is added to make up losses of free acid in the electrolyte in the copper electrolysis and the nitric similarly in the parting plant. The chloride is added to the copper electrolyte chiefly to precipitate antimony as oxychloride, although it has been claimed by many to have positive value as an addition agent.

Fortunately most of these process supplies carry but little in the way of metallurgical impurities. The notable exceptions are blast-furnace fluxes, sodium salts and sulphuric acid.

As refinery slags are always strongly acid, being made by a union of metallic bases with siliceous furnace material, it is necessary to find lime and iron to replace the copper in these slags. The natural source of iron in the vicinity of most refineries is pyrites cinder resulting from the manufacture of sulphuric acid. As arsenic is commonly associated to a greater or less degree with iron pyrites, more or less of this element may be introduced in this manner.

In the same way sulphuric acid made by burning pyrites is likely to contain considerable quantities of arsenic as an impurity, and unless purified acid is used it may be a heavy contaminating agency, since where sulphate salts are made as a by-product the acid purchases are large.

In like manner any nitrate of soda used in the silver building boiling tanks as an oxidizing agent or sodium chloride added to the electrolyte directly bring about a concentration of sodium sulphate which may be objectionable.

B—Exits

A complete analysis of what may be called "exits" for impurities was given in the article "Sources of Metal Loss in Copper Refining" (METALLURGICAL AND CHEMICAL ENGINEERING, July 1, 1916). Based on this, eliminating such items as do not bear directly on our immediate problem, we may classify the exits as (a) outgoing commercial products, (b) slags and (c) stack gases.

The ideal process would eliminate the two latter products entirely and send all of the impurities out as commercial products. Practically not only do several elements escape in their entirety, but excepting copper, silver and gold, the remaining are recovered at far from 100 per cent efficiency.

The tendency to-day is to check stack losses so that in time there will be but two outlets, the one to commerce and the other to the slag dump.

When markets are unsatisfactory some of the products can be stored, as has already been the case with selenium, tellurium and bismuth.

C—Distribution

The distribution of impurities depends partly upon their chemical characteristics and partly upon the metallurgical practice of the individual plant.

In the first place, the cathode will contain measurable quantities of all impurities found in the anodes, although there is room for some discussion as to what proportions of these arrive by electrolytic deposition, by inclusion of electrolyte and by mechanical contamination by anode slimes. (See Addicks, Trans. Am. Electrochem. Soc., vol. xxvi, p. 51.) The percentage of anode impurities found in the refined copper may be seen by direct comparison of average analyses over a long period of operation, as in Table V.

The four elements showing a cathode recovery of

TABLE V—METALLURGICAL EFFICIENCY OF REFINING

Element	Anode	Wirebar	Per Cent of Original Impurity	Efficiency of Refining
Copper.....	99.030	99.939	.....	.....
Silver.....	0.1687	0.00131	0.78	99.22
Gold.....	0.0051	0.000013	0.25	99.75
Sulphur.....	0.0075	0.0029	38.60	61.40
Nickel.....	0.3200	0.0037	1.15	98.85
Lead.....	0.0567	0.0020	3.52	96.48
Arsenic.....	0.0523	0.0015	2.87	97.13
Antimony.....	0.0499	0.0034	8.32	91.68
Bismuth.....	0.0051	Trace	.....	.....
Tellurium.....	0.0282	0.00015	0.53	99.47
Selenium.....	0.0682	0.00040	0.59	99.41
Iron.....	0.0181	0.0039	16.10	83.90

over 99 per cent are silver, gold, selenium and tellurium, none of which dissolve in the electrolyte. Therefore, the mechanical contamination by anode slimes is less than one per cent. Then we have nickel at 1.15 per cent; this element, while present in oxidized form in the slimes, goes chiefly into solution as sulphate. The same is true of arsenic which, however, forms a light slime which readily attaches itself to the cathode. Lead comes not only from the anodes but from the tank linings, so that the efficiency is not quite true in this case. The same is true in lesser degree of antimony, as hard lead is universally used to-day for tank linings. Antimony is further precipitated from the electrolyte as oxychloride, as previously described, entering the float slime. A characteristic analysis of this sediment is given in Table VI.

TABLE VI—ANALYSIS OF FLOAT SLIME

Element	Per Cent
Copper.....	3
Arsenic.....	13
Antimony.....	30
Silver.....	8
Lead.....	4
Iron.....	0.3

When we come to consider the efficiency of refining with regard to iron and sulphur we must remember that both these elements are introduced in the melting of the cathodes, the former in the rables and tools used and the latter in the fuel and ladle charcoal, and we also have sulphate sulphur from the electrolyte, so that the figures are misleading.

We may say in a general way, therefore, that the efficiency of refining is very high and that the cathode copper offers a very small outlet for anode impurities; further, that the great bulk of those impurities which are soluble in dilute sulphuric acid will concentrate in the electrolyte.

The balance of the impurities must go into the slimes and we can attempt a measure of this by comparing the assays of the anodes and of the raw slimes as they come from the tanks except for boiling free of soluble salts. This is done in table VII.

The last two columns of table VII assume that 99.5

TABLE VII—CONCENTRATION OF ANODE IMPURITIES IN SLIMES

Element	Anode, per Cent	Slimes, per Cent	Per Cent Anodes x54.4	Per Cent Recovered
Copper.....	98.14	14.3	.....	.....
Silver.....	0.417	35.0	35.2	99.5
Gold.....	0.00711	0.643	0.600	(107)
Nickel.....	0.314	5.25	26.5	19.8
Arsenic.....	0.236	2.68	19.9	13.5
Antimony.....	0.0906	5.35	7.6	70.0
Bismuth.....	0.0088	0.46	0.74	61.9
Sulphur.....	0.0037	1.69	0.31	(541)
Iron.....	0.0123	0.17	1.04	16.4
Lead.....	0.0456	2.44	3.85	63.4
Selenium.....	0.0479	5.70	4.04	(112)
Tellurium.....	0.0318	2.69	2.68	(100)
Zinc.....	0.0100	Trace	0.84	None
Insoluble.....	0.1213	6.60	10.2	64.5

per cent of the silver was in the slimes the remaining 0.5 per cent being in the cathodes. On this basis the recovery in the slimes of the remaining elements has been calculated. Of course, the gold, selenium and tellurium should also show a recovery of about 99.5 per cent, and the discrepancies simply indicate that the correspondence between identity of slimes and anodes is not quite exact.

The sulphur shows a large excess due to the fact that the sulphur in the sulphuric acid of the electrolyte has combined with some of the impurities as sulphates which have not proved readily soluble.

Nickel, iron, zinc and arsenic, as would be expected, show small recoveries; the first three form readily soluble sulphates and arsenious acid is quite soluble in the electrolyte. Nevertheless, with the exception of zinc the slimes retain some of even these elements.

Lead which has a but slightly soluble sulphate, antimony, which is precipitated as oxychloride, bismuth and siliceous matter show high but not perfect recoveries.

Much of this group goes into the float slime which is largely separated out before the heavy slimes are sent to the silver building and this, if corrected for, would make a nearly complete slime recovery.

An analysis of the electrolyte corresponding to the example given above would be about as stated in table VIII.

TABLE VIII—REPRESENTATIVE ANALYSIS OF ELECTROLYTE

Specific gravity.....	1.226
Per cent free acid.....	12.03
Per cent copper.....	2.94
Per cent nickel.....	1.48
Per cent chlorine.....	0.0031
Per cent arsenic.....	0.916
Per cent antimony.....	0.0350
Per cent iron.....	0.060
Per cent bismuth.....	0.0026
Per cent zinc.....	0.0166
Per cent alumina.....	0.0595
Per cent calcium sulphate.....	0.1348
Per cent magnesium sulphate.....	0.0370
Per cent sodium sulphate.....	0.5048

A comparison of the relative values of the impurities in the electrolyte with those in the anodes confirms in a general way the distribution already shown. It is evident that in this particular case nickel is the controlling impurity and that any system of purification of the electrolyte which will hold this element at the desired concentration will automatically take care of arsenic and other impurities.

D. The Requirements of Refined Copper

This subject is of sufficient importance to be reserved for treatment at length in a future article.

E. Purification of the Electrolyte

Any system of purification must regularly withdraw sufficient electrolyte to control the amount of the chief impurity. For example, in the analysis given in table VIII, nickel is the element which would first grow to undesirable concentration, although arsenic is a close second and the maximum allowable values of various elements depend upon conditions under which an individual plant is operating. Both nickel and arsenic have been allowed to reach 3 per cent in the electrolyte without disaster in certain local and temporary cases. The first thing is therefore to ascertain what quantity of electrolyte must be daily withdrawn.

I. PURIFICATION BY CEMENTATION UPON IRON

The early methods of purification consisted simply in cementing the copper upon iron and throwing the copper-free liquor away. The scrap iron would be piled in a lead-lined tank, the liquor run in and brought to a boil by heating with steam and at the end of an hour

a bright iron rod would not tarnish when introduced, indicating complete precipitation of the copper. The liquor was then run to the sewer and occasional clean-ups of cement copper made.

Theoretically but 0.88 lb. of iron is required to replace one pound of copper. In this case, however, the scrap contained more or less inert graphite and iron oxide, the iron precipitated more or less arsenic, etc., and the high free sulphuric acid actively attacks the iron so that as much as two pounds of scrap iron are often required per pound of copper precipitate.

The cement is generally quite foul running about as shown in table IX:

TABLE IX—ANALYSIS OF TYPICAL CEMENT FROM DISCARDED ELECTROLYTE

Copper, per Cent	Iron, per Cent	Arsenic, per Cent	Silver, Oz. per Ton	Gold, Oz. per Ton
70	5	10	15	0.1

The silver and gold come, of course, from suspended slimes carried over from the electrolytic tanks.

While this method has the advantages of simplicity in operation and small plant required, it makes a foul cement which requires retreatment, runs up a heavy bill for scrap iron and entirely wastes both the free and combined sulphuric acid content of the electrolyte.

Nevertheless, it is still used in some small plants, and is always considered a legitimate emergency measure for dealing with a bad electrolyte.

II. THE BY-PRODUCT MANUFACTURE OF BLUESTONE

The next purification method developed was to go into the manufacture of commercial bluestone, using electrolyte as a raw material. The process consisted of four steps, as shown in Fig 1: Neutralization of free acid by means of anode copper, concentration of neutral liquor by boiling, crystallization of heavy liquor, and cementation of mother liquors.

In this way the entire free acid content as well as that already combined with copper in the electrolyte is recovered as sulphate of copper except that discarded in the final mother liquors.

In this way the iron tanks do not receive any liquor until the impurities have risen to a point where bluestone of commercial purity can no longer be made by fractional crystallization.

Also, as anode copper is used for neutralizing the free acid a certain amount of copper is refined, the silver and gold remaining as slime in the shot towers, and

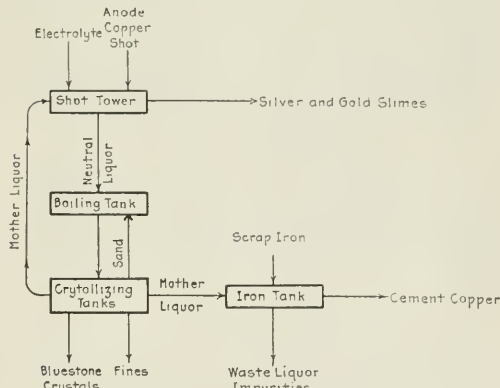


FIG. 1—BY-PRODUCT BLUESTONE PLANT

therefore the by-product plant is entitled to a certain amount of tolls to be credited against its operating expense.

Then there is still the legitimate profit from the market price of bluestone, so that it is possible to place the purification system on a revenue-producing basis.

On the other hand, the plant required is bulky, it is dependent for results upon the market for bluestone which at times is badly overproduced and finally the plant is strictly limited to a predetermined capacity, and therefore uses the electrolyte as a reservoir for fluctuating amounts of anode impurities. Also where very foul anodes are to be treated the bluestone plant becomes enormous.

However, as this system is more or less used to-day, though generally in addition to other methods, some account of the process will be given.

1. Capacity

A building 50 ft. by 150 ft. ground plan will produce about 140,000 lb. of bluestone a month. This is equivalent to about 35,000 lb. of copper, but about three-quarters of this comes from the shot copper and only 9000 lb. is from the electrolyte, so that this plant would represent the withdrawal of but 100 cubic feet a day of electrolyte.

2. Shot Towers

Copper is not readily soluble in dilute sulphuric acid, especially in the presence of various impurities. In order to promote the rate of solution the liquor is heated and poured over the copper intermittently so as to promote the oxidation of the copper. The towers are built in various ways in order to accomplish this, but the simplest method is to spray the hot liquor over the top of the bed and let it trickle through.

The copper itself is cast in the form of so-called shot in order to increase the surface exposed. Shot is a mass of small hollow irregular spheres, and as these dissolve away, the mass crumbles and this tends to prevent packing. It is made by adding a little matte to an anode furnace charge to lower the pitch and then pouring a thin stream of metal through a blast of air into a well filled with water. More or less minor explosions occur, but if the procedure is skillfully carried out the result is a surprisingly light mass of detached globules ranging from $\frac{1}{4}$ in. to $1\frac{1}{2}$ in. in diameter.

Underneath the shot towers is a well, and here the silver and gold slimes wash down as the copper is dissolved and settle out. These are periodically collected and sent to the silver refinery to be smelted along with the anode slimes from the electrolytic tank house. It is impossible absolutely to neutralize the free acid in the electrolyte in this way in a reasonable time, but by repeated circulation at high temperature it is possible to bring it below 1 per cent. The temperature must be above 150 deg. Fahr. for effective work, and the time required is from four to seven days in a plain tower.

3. Boiling Tanks

The boiling tanks are lead-lined open tanks with closed steam coils and the liquors from the shot towers are here concentrated as far as steam at a reasonable pressure for lead pipes will carry them. This is about 38 deg. Beaumé and corresponds to 9 or 10 per cent copper. The time required for a batch is about eight hours.

4. Crystallizing Tanks

The crystallizing tanks are shallow, open, lead-lined tanks provided with strips of lead hung from cross bars on which the crystals grow. The liquor from the boiling tanks is allowed to stand quiescent in these tanks for five days, which time experience has shown to be

the best. A longer period results in more or less resolution, while forced cooling by means of cooling coils results in a crop of small and less pure crystals.

The choice large crystals grow chiefly as trees on the lead strips. At the bottom of the tanks a mass of fine crystals forms.

The crystals are removed after the mother liquor has been pumped out and are then generally dried by hot air and screened to separate the coarse and fine, each class being packed in barrels for shipment. The fine sand is sent back to the boiling tanks and recrystallized.

The best crystals physically are made from truly neutral liquor. Should the liquor carry 2 per cent acid or over, the crystals are likely to be hygroscopic and are not a prime market product. Also calcium sulphate, if present in the liquor to any extent (this salt is sparsely soluble in such solutions), will form white "whiskers" on the crystals.

The main physical question is, therefore, to obtain a maximum proportion of large, clean, dry crystals. An ordinary yield is 47 per cent large crystals, 9 per cent pea and 44 per cent sand.

Chemically the problem is to keep the mother liquor down in impurities to a point where fractional crystallization is sharp enough to make a commercial salt. The alternative is to dissolve and recrystallize. The effect of recrystallizing is shown in table X, where "bottoms" have been dissolved and crystallized, forming crystals and a second crop of bottoms, but leaving most of the arsenic and antimony behind in the new mother liquor.

TABLE X—REMOVAL OF IMPURITIES FROM BLUESTONE BY RECRYSTALLIZATION

	Per Cent Arsenic	Per Cent Antimony
Original "bottoms".....	0.434	0.113
New crystals.....	0.076	0.013
New bottoms.....	0.117	0.014

$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ contains approximately 25.4 per cent copper, 38.5 per cent combined acid and 36.1 per cent water of crystallization. Ninety-nine per cent crystal should, therefore, run slightly better than 25 per cent copper and 98 per cent slightly less and bluestone is generally considered to carry one-quarter copper. In table XI are given some random analyses of the products from several plants.

TABLE XI—REPRESENTATIVE ANALYSES OF BLUESTONE

Source	Remarks	Per Cent Copper	Per Cent Iron	Per Cent Nickel	Per Cent Arsenic	Per Cent Antimony
A	Coarse	24.97	0.195	0.358	0.018	0.006
A	Fines	24.72	0.215	0.419	0.040	0.009
A	Seconds	23.25	0.250	1.250	0.090	0.017
B	"Alabundous"	26.18	0.500	1.850	0.068	0.030
C	Coarse	25.22	0.025	0.105	0.003	0.005
D	Coarse	24.80	Trace	..	0.150	0.018

The wide range of the impurities in the different products in table XI is due chiefly to the difference in the electrolytes at the various plants. The salt showing 26.18 per cent copper had been overdried, thereby losing some of the water of crystallization; this makes a dirty white crystal and is also a source of loss to the producer, as copper contents above the guaranteed amount are not paid for.

5. Mother Liquors

The mother liquors from the crystallizing tanks are returned to the boiling tanks and reconcentrated with fresh liquor from the shot towers. As the impurities grow in concentration, however, the bluestone is in-

creasingly contaminated and a point is reached where a proportion has to be diverted to the iron tanks to be worked up into cement copper.

Sometimes a foul copper-nickel-iron sulphate is crystallized from such liquors before cementing. An example of such a salt is shown in table XII:

TABLE XII—COPPER, NICKEL, IRON SULPHATE FROM MOTHER LIQUOR

Per Cent Copper	Per Cent Nickel	Per Cent Iron	Per Cent Arsenic	Per Cent Antimony	Oz. per Ton Silver
9.52	11.50	1.19	0.23	0.024	0.15

The silver is, of course, due to contamination by suspended slimes from the shot towers. Similar quantities and a proportionate amount of gold is found in bluestone when anode copper is used for shot. A salt of this character has no commercial use, but is a good starting point for nickel recovery as another by-product.

III. PURIFYING WITH INSOLUBLE ANODE TANKS

Where but little nickel is present and arsenic is the predominant impurity, a simple process based upon the use of insoluble anode tanks is sometimes employed.

A certain amount of electrolyte is diverted to a set of tanks provided with lead anodes and operating in cascade so that practically all of the copper and arsenic are plated out and the equivalent sulphuric acid is liberated. The treated liquor is returned to the electrolyte.

This uses a considerable amount of power, but recovers the acid and calls for no scrap iron. It takes three tanks in cascade to bring the copper and arsenic down to 0.1 per cent or less. The first tank will operate at about 85 per cent current efficiency and produce cathodes, which may with reasonable safety be included in the fine copper output; the second will run at perhaps 50 per cent efficiency and the cathodes reserved for casting copper or anode changes; the last tank runs at a very low copper efficiency and produces a sludge consisting of about half copper and half metallic arsenic. Much of the latter can be eliminated from this by roasting and sublimation, if desired. Such insoluble anode tanks evolve arseniuretted hydro-

gen, which is very poisonous, and they should therefore be located out of doors.

This method is limited by the permissible amount of impoverishment of the electrolyte in copper; if carried to extremes it is evident that the whole copper content of the electrolyte would be withdrawn, the acid being correspondingly increased. On the other hand, when nickel is practically absent from the anodes and the copper withdrawals necessary to hold down the arsenic do not exceed the normal growth of copper in the electrolyte, it is a satisfactory solution of the purification problem.

IV. COMPLETE CYCLICAL PURIFICATION

The method of purification of the electrolyte in general use among copper refineries to-day is shown in diagrammatic form in Fig. 2. Electrolyte is diverted to insoluble anode tanks at a rate just sufficient to keep the determining impurity at the desired point. This impurity is almost always nickel or arsenic and generally the former.

The first step in the process is the same, therefore, as that just described in the preceding paragraph, but the liquor resulting therefrom instead of being returned to the electrolyte is sent to a steam boiling tank where it is concentrated as in the manufacture of bluestone up to about 40 deg. Beaumé.

The liquor is then transferred to a tank made of boiler plate, as, being nearly copper-free and of high sulphuric acid content, it is no longer seriously corrosive to iron. This evaporator is heated by direct fire until the syrup reaches about 70 deg. Beaumé, at which strength practically all the impurities except the small amount of arsenic which has escaped the insoluble anode tanks and the sodium and potassium salts have been precipitated as anhydrous sulphates.

This heavy liquor with its suspended solids is then tapped on to a sand filter where the bulk of the strong acid is filtered out. The mushy salts are then shoveled on to a draining board and finally into a sucking tub, where the acid is displaced with a very small quantity of water.

The partly washed salts are then shoveled on to a drying floor where the water is gradually taken up as water of crystallization and the mass sets into lumps of partially hydrated sulphate, which may be readily handled and shipped and is in good physical shape for charging into a furnace for the recovery of metal values.

If the strong acid filtrate is chilled before returning it to the electrolyte much of the sodium sulphate will be thrown out. Practically this occurs at ordinary winter temperatures at most of the plants.

This process is completely cyclical except for the combined acid sent out with the crude nickel salts and such acid losses as may be incurred by fumes from the fire evaporator. The nickel is recovered in a form reasonably acceptable to a nickel smelter; but little low-grade cathode copper is made, and the arsenic could be separately recovered were it worth while to do so.

The objection still applies that the electrolyte may be robbed of too much copper and this has especial force when discussing nickel, as much of the anode nickel appears to dissolve electrochemically so that more copper is plated out at the cathode than is electrochemically dissolved at the anode.

The remedy, in case of trouble of this character, is to build shot towers and allow a certain proportion of the regular electrolyte to trickle through them. As the solution so diverted has always high free acid content, such towers are more active than in a bluestone plant, where complete neutralization is the object.

The chemical separations are not sharp and some lee-

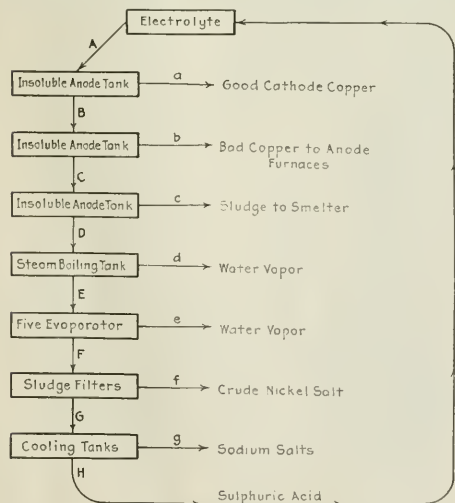


FIG. 2—MODERN METHODS OF PURIFICATION OF ELECTROLYTE

way has to be left for circulating impurities due to this fact. An example of crude nickel salt made in this way is given in table XIII:

TABLE XIII—ANALYSIS OF CRUDE NICKEL SALT

Per Cent Water	Per Cent Copper	Per Cent Iron	Per Cent Nickel	Per Cent Arsenic
17.0	0.57	1.76	28.45	0.02

F. Recovery of Insoluble Impurities from the Anode Slimes

This question involves the whole metallurgy of the silver refinery and this will be taken up separately in another article.

The Testing of Lubricating Oils

By Hugh K. Moore and G. A. Richter

The selection of the most suitable lubricating oil for plant operation depends upon three things: the specific conditions under which this oil is to be used, the cost of the lubricant and the cost of power.

A lubricant which is ideal for one specific purpose may be entirely unsuitable for service with another type bearing, or may prove very uneconomical in another plant where the cost of power is different. The characteristics of the oil which determine its suitability may be ascertained in many ways, but there is no one machine which will combine all the characteristics to be considered and allow a general conclusion to be drawn regarding its net value.

As inferred above, the significance of test results made on lubricating oils depends entirely upon the "type" of lubrication under consideration, and conversely, the particular form of lubrication which is of immediate interest determines the test methods by which one selects the oil most suitable. Often, depend-

ing on the price of power and price of oil, it is wise not to use the best grade of oil to realize most economical results. Many test machines have been designed and built for testing the physical properties of lubricating oils, each serving the particular purpose of the designer.

The experiments and tests which we will refer to in this article were conducted with a type of bearing which measures relatively the durability and also the internal friction or "power consumption" of the oil in question. The apparatus as employed in these tests aims to duplicate that type of bearing in which the oil is present in excess.

A photograph and sketch of this machine are shown in Figs. 1 and 2. It consists essentially of the bearing cone *A* which is rotated within the conical sleeve *B*, the desired pressure being maintained by a suspended weight *W* on the shaft *C*. The machine is operated by means of a 1/2-hp. direct-current motor through a gear drive. The conical sleeve is made high enough to use cones of different size and is jacketed in order to maintain any desired temperature either high or low at the bearing surface, and also to provide means for bringing the temperature of the bearing to any selected temperature just previous to each successive run in a series.

The power consumption or friction during the operation is measured by means of ammeter and voltmeter. Knowing the efficiency of the motor, the results obtained by using different lubricating oils in the conical bearing become directly comparable. This comparison may also be realized by operating each time with a pre-determined power input. The motor bearings and gear drive are kept lubricated with a large excess of the same lubricant all the time, and thus this factor is practically eliminated.

Provision is made for several different methods of testing the oil in question. The revolving cone is furnished with a spiral feeding groove through which the oil may be brought to the bearing surface. The shaft supporting the weights is hollow and allows the oil after feeding through the bearing groove to travel down to a small oil pump which pumps the oil back into the conical bearing, thus completing the cycle. During this operation the desired readings are taken. If the temperature rise of the bearing is of essential importance, a thermometer is suspended in the excess oil over the

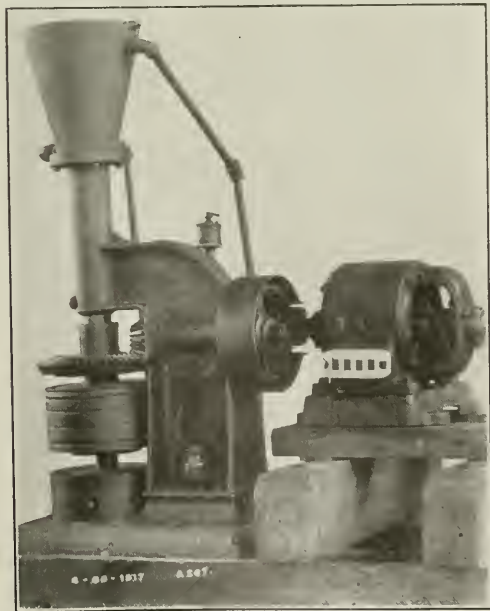


FIG. 1—TEST MACHINE

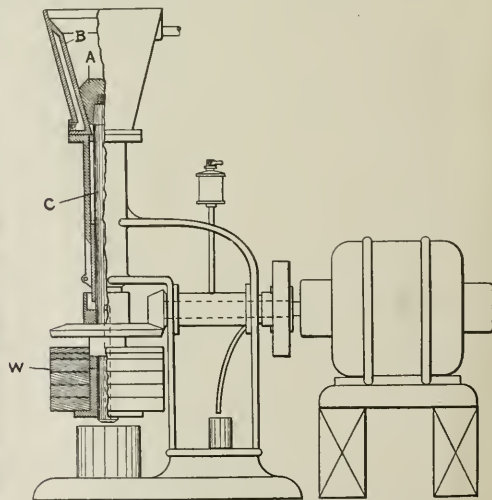


FIG. 2—DIAGRAM OF TEST MACHINE

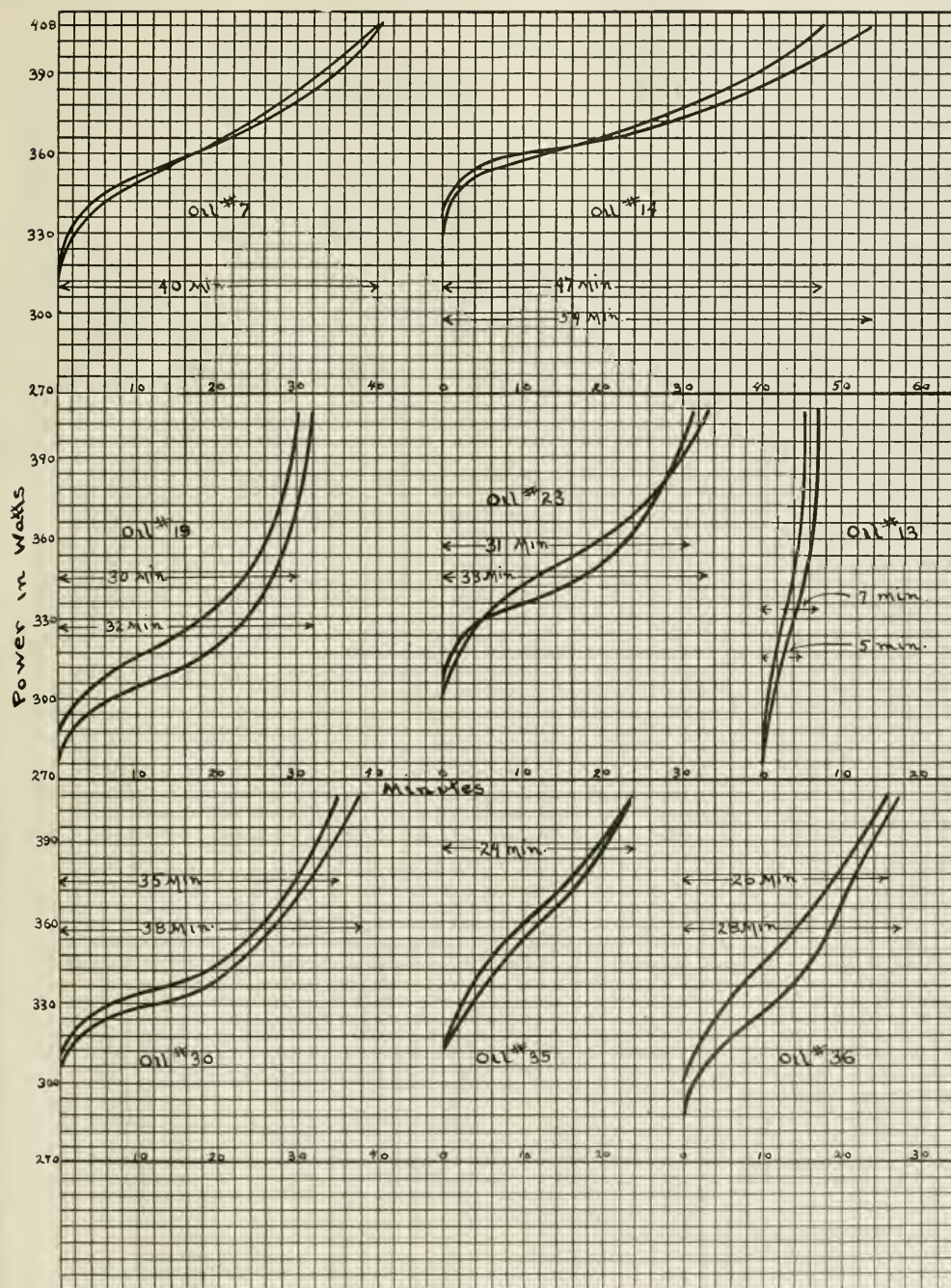


FIG. 3—SUMMARY OF CURVES

bearing. Where the power consumption is the determining factor, the input in watts is plotted against time. In this way the "durability" or "breaking down" qualities of the oil may be studied. If the specific case of

lubrication which is being duplicated assumes a given constant temperature, this temperature may be realized by means of the jacket about the bearing. Moreover, the speed, pressure of bearing, and material of

the bearing, may be varied at will to suit the case in question. In carrying out tests as indicated above the authors record:

Material of bearing.
Speed of shaft.
Pressure per square inch.
Type of lubricant.
Initial temperature.
Final temperature.
Curve—power vs. time.
Curve—temperature vs. time.

A second method which may be employed in testing the oil consists in eliminating the oil pump and dropping the lubricant onto the bearing as needed. The oil is regulated by keeping the power input below a predetermined limit and the oil per hour is thus obtained. In carrying out such a test, the lower end of the oil groove in the bearing is first plugged so as to keep the oil from escaping through the groove. A drop of oil is added to the dry bearing and the machine started. When the electrical instruments show the predetermined maximum power input, another drop is added, and the machine allowed to continue to operate until the same maximum power input is registered. The consumption of lubricant per unit time is the basis of comparison.

A third method which may be used in testing the lubricant is to plug the lower end of the groove as before, start the machine without the circulating oil pump, add a certain amount (3 cc.) of oil to the bearing, and record the power input each minute. The machine is allowed to run until a maximum allowable power input is reached, and the power is plotted against time. By studying such a curve one can obtain valuable information regarding the internal friction (power consumption) and also the durability of the oils in question. The authors, for the most part, have employed the last mentioned method of using the machine, although the other methods were also used to advantage.

In carrying out the specific series of runs to be described the operating conditions were as follows: The bearing cone had a vertical angle of 30 deg. The lower end of the feeding groove was plugged with solder. A weight of 100 pounds was attached to the shaft, thus realizing a normal bearing pressure of 1.5 lb. per sq. in. The shaft was operated at a speed of 80 r.p.m. The set includes a series of 8 types of machine oils obtained from different companies. Each run was carried out as follows: The machine was started and three cubic centimeters of the given oil added to the bearing, power readings were taken and continued at intervals of one minute. In this particular series the amperage of the motor was allowed to reach 3.4, whereas the voltage was kept constant at 120 volts. At the end of each run the bearing was cooled to the same starting temperature of about 20 deg. C. by running cooling water through the jacket of the conical sleeve. Several runs were made on each oil for check results. It is to be noted that the absolute number of minutes which is required for the power to reach the above limited amperage is not the only measure of the true value of the oil. To determine the most suitable oil the curves must be plotted and studied with care. The data and curves are given in Table I and Fig. 3.

It is of interest to note that the oil which stands up for the longest period of time without exceeding the allowable power consumption requires a comparatively higher power input *during* that interval of operation than do the other oils which reach the same predetermined maximum in shorter time. This indicates that although the one oil possesses greater durability, most of the other oils require a much smaller power consumption during their time of operation. Before

Number of Oil	Initial Temperature, Deg. C.	Final Temperature, Deg. C.	Increase Temperature, Deg. C.	Time in Min., Run I	Time in Min., Run II	Average Time
7.....	24.0	36.5	12.5	40	40	40.0
13.....	26.5	30.5	4.0	5	7	6.0
14.....	22.0	35.5	13.5	47	54	50.5
19.....	23.0	36.0	13.0	30	32	31.0
23.....	25.0	38.0	13.0	31	33	32.0
30.....	23.0	37.0	14.0	35	38	36.5
35.....	22.0	32.0	10.0	24	24	24.0
36.....	20.0	37.0	17.0	26	28	27.0

Note—Normal pressure per square inch = 1.5 lb.

End of groove in cone plugged.

No circulation of oil.

3 cc. lubricant used for each test.

Bearing material = brass.

it is possible to select the most economical oil, it is necessary to know the cost of the lubricant and the cost of power. The most economical oil is not necessarily the most suitable, however, since the factors such as bearing temperature, gumming and cold test must also be considered.

Viewing the problem from an economic standpoint only, and disregarding for the present the other factors mentioned in the preceding paragraph, the general conclusion to be drawn from the above curves is as follows: With the flooded type of bearing (such as used) oil 14 is by far the most durable. Its average power consumption during the long period of operation is, however, greater than the other oils. Oil 19 and oil 30 last for a shorter interval but during that interval the average power consumption is much less. In other words, if cost of power is the deciding factor, then oil 19 and oil 30 are probably more economical to employ than is oil 14, the proportional saving depending on the relative costs of the power and of the oil. Oil 13 and oil 35 appear unsatisfactory in both respects, and unless they possess some other very strikingly redeeming feature not indicated by this test, they cannot be considered in a class with the other test samples.

The investigator may alter his chosen maximum power input and thus slightly modify his numerical conclusion. The object in selecting the maximum load is to duplicate as nearly as possible the allowable frictional load which the local conditions will warrant. As employed above, each type and kind of bearing must be treated in its own individual way, and the investigator must decide on his premise before he may proceed with the test and draw a logical conclusion.

One decided advantage of this form of tests lies in the fact that due to its conical design, even with continued wear, the bearing surface is not altered materially. Practically each individual factor which determines the suitability of a lubricant may be altered at will without disturbing the remaining factors. Thus one can change the speed, pressure of bearing, type of bearing, temperature, or size of bearing each individually or all together. Moreover several types of lubrication may be realized on the same apparatus with but slight change in assembly.

Other oils have also been examined in a similar manner as those above described. Among these were black oils and cylinder oils. The steam jacket was used to advantage in tests on the heavier lubricants.

SUMMARY

- (1) An oil tester such as here described proved of value in selecting the lubricant for a specific purpose.
- (2) Curves of experimental results are given from which conclusions are drawn.
- (3) Other methods of testing oils in this same apparatus are outlined.

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Producer Gas and Its Industrial Uses*

By F. W. Steere

One of the greatest problems now confronting industry is undoubtedly the fuel problem. It is the same old story of prodigal waste until we suddenly find ourselves face to face with a real shortage.

The subject of this discussion is to consider the possibilities of one of the methods of utilizing soft coal, that is, by converting it into producer gas. Producer gas is by no means the panacea for all our ills, but it has its place, and our duty now is to determine to what extent its use can be applied in conserving our natural fuel supplies.

In order to have clearly in mind the distinguishing characteristics of producer gas, we will briefly outline, for the purpose of this discussion, the different kinds of commercial gases most frequently used:

Natural Gas.—Made by secret processes of nature, composed largely of methane, usually running about 1100 B.t.u. per cubic foot.

Oil Gas.—Made by bringing oil in contact with heated surfaces. The resulting constituents and B.t.u. vary for a given oil through a wide range, depending on the temperature of the heated surfaces.

Coal Gas.—Made by the destructive distillation of soft coal in externally heated retorts with the exclusion of air. The resulting coke is withdrawn at intervals, and the retorts recharged with coal. This is the gas most generally made and distributed for domestic use, having a calorific power of approximately 600 B.t.u. per cubic foot.

Coke Oven Gas.—A by-product from the manufacture of coke. It runs somewhat lower than coal gas in B.t.u., but in general may be considered as practically the same. Theoretically the process of manufacture is the same as coal gas, the practical difference being in the size and shape of the retorts.

Water Gas.—Made by the decomposition of steam coming in contact with incandescent carbon, the resulting gas being largely hydrogen and carbon monoxide. This is an intermittent process, as the carbon must be blown, at frequent intervals, with air to bring it back to incandescence.

Carburetted Water Gas.—This is a mixture of water gas and oil gas and is frequently mixed with coal gas and distributed for domestic use.

Producer Gas.—As referred to in this paper, it is the product of an incomplete combustion of carbonaceous material—for the purposes of this discussion—soft coal. It differs from ordinary retort gas in that the whole of the combustible part of the fuel is gasified—no residue or coke is left. The heat required for gasification is obtained from the combustion of a portion of the charge of solid fuel which is to be gasified. Producer gas is almost universally enriched by the use of steam blown through the fuel bed with the air—its use being necessary for the practical operation of the gas producer. The volatile constituents of the resulting gas are carbon monoxide and hydrogen, with about 50 per cent of nitrogen. The calorific power of producer gas from soft coal is ordinarily from 140 to 160 B.t.u. per cubic foot.

It is not within the scope of this paper to discuss the chemistry of gas producer reactions, as these are familiar to all of you. We will rather confine our discussion to the problem arising from the commercial application of the gas after leaving the producer, and the types of furnaces in which this gas can be most effectively utilized.

For many years producer gas has been successfully

used in metallurgical work for heating large furnaces, for melting glass, etc. These operations are carried on with hot producer gas, that is, the gas from the producer offtake, which is usually at a temperature of from 1200 to 1400 deg. Fahr., is led directly to the furnaces through brick-lined flues. Producer gas made from soft coal carries large quantities of tar, soot and dust in suspension. It is impossible to keep a large part of this solid matter from being deposited in the flues between the producer and the furnaces. This deposit must be periodically removed by "burning out." The flues are usually so arranged that they may be readily connected to a stack by means of a damper, and, while hot, air is introduced at intervals along the flues, resulting in the combustion of the material deposited. It is obvious that this gas uncleaned, and at a relatively high temperature, could not be conducted for any considerable distance, for instance to a number of small furnaces, without an excessive investment in flues. It would also be very difficult to keep these flues from becoming stopped with the deposits of tar, etc., as the solid matter tends to precipitate much more rapidly as the gas is cooled.

The only practical means for utilizing producer gas in the great variety of heating operations which are found, for instance, in the automobile industry, is to clean the gas completely of all suspended matter and cool it to normal room temperatures. It then can be distributed through any system of piping around a factory, the same as ordinary city gas.

The big problem has always been to make a gas free from both tar and soot. This difficulty of getting clean gas has undoubtedly had more to do with the slow development and adoption of producer gas than all other things combined.

Two general types, or classes, of producers have been developed, the distinguishing characteristics of which are the methods of cleaning the gas:

1. Producers where it is attempted to convert all of the tar to a fixed gas before leaving the producer.

2. Producers which make a tarry gas and rely on outside apparatus for cleaning it.

Suction and pressure producers are found in both of these classes.

The producers of the first-class are built on the theory that if the hydrocarbon vapors, tar oils, etc., which go to make up the very complicated combinations of material that are usually designated as "tar," are brought in intimate contact with highly heated surfaces, these tar constituents will be cracked to fixed gases. The down-draft producers, double-zone producers, and underfeed producers illustrate this class. In these machines the gas is made to pass through the heated portions of the fuel bed, relying on the contact with the incandescent coke to bring about the cracking.

All of the simpler forms of producers, where the fuel is charged at the top and steam and air are blown in at the bottom, come under the second class. The tarry vapors which are distilled from the top of the producers, obviously pass out with the gas and must be cleaned by some external means. This problem of removing tar from gas made in producers of the second class, has been attacked from almost every conceivable angle, such as washing, scrubbing, complicated spray systems, deflectors, centrifugal and whirling machines of almost infinite variety, filtering, pressure and sudden expansion, and precipitation by high-tension electrical discharges.

The high-tension electrical process for detarring gas was invented by the author in 1911. The following extract from a paper* entitled "An Electrical Process for

*A paper read on May 17, 1917, before the Society of Detroit Chemists, Local Section, American Chemical Society.

*METALLURGICAL AND CHEMICAL ENGINEERING, vol. XII, p. 775, 1914.

Detarring Gas," which was read before the American Gas Institute in 1914, describes what takes place in the "ionizer" where the gas is passed through the high-tension electrical discharges:

"An opportunity was provided at the Detroit plant of the Smet-Solvay Company to work out these ideas and develop the theory on which this work is based. This theory, although for from complete, has proven sufficiently accurate to guide us in perfecting a detarring process which is in commercial use to-day.

"In attempting to briefly outline the electrical action, we must keep in mind first that the gas molecules themselves possess both positive and negative electrical constituents which can be separated by X-rays, beta and gamma rays of radium, brush discharge from points, corona discharge from wires raised to high potential, ultra violet light, etc. This process of separating neutral gas molecules into electrically charged parts or ions is called 'ionization.' It is outside the scope of this paper to attempt to discuss the ionic theory, but it should be noted that ions as such are very unstable and cease to exist, that is, recombine to form neutral molecules, almost the instant they are outside the ionizing influence. A very few molecules are continually splitting up, presumably because of the trace of radioactive substances found in most gases as well as in the atmosphere.

"Professor Millikan of the University of Chicago has studied the movements of a small drop of oil between two oppositely charged condenser plates when attacked by atmospheric ions. The drop receives a charge when atomized, so by throwing on and off the electrical field, the drop is made to beat up and down between the plates. The instant an ion attaches itself to the drop the fact is made known to the observer by its change in speed, this change depending on the sign of the ion and the charge on the drop. The important and interesting thing to note is that with over a thousand drops studied in this way, the change of speed was always exactly proportional to the number of ions attached to the drop.

"Let us recall that there are about 27,000,000,000 molecules in 1 c.c. of ordinary air and that each molecule may be separated into at least two ions. When just one of the possible 54,000,000,000 ions per cubic centimeter attached itself to the oil drop it instantly caused an appreciable change in its velocity. Imagine then the violence with which this drop would have been thrown about if all the molecules surrounding it had been ionized.

"This is just the condition we bring about in the electrical detarrer. The gas carrying the minute tar globules is swept into an intense ionizing field. Billions of gas molecules on every side are being torn apart. The resulting ions rush madly about in their effort to recombine. The unsuspecting tar globules find themselves in a storm center of unseen forces hurling them in every direction. The time occupied in the passage of the tar particles through the electric field is brief and it might naturally be supposed, as it heretofore has been, that an aimless to-and-fro movement of them would be the result of the applied energy. It would, however, be hard to conceive of a condition more favorable to impact between tar particles, and experience shows that either because of this impact, or for some reason as yet unknown, agglomeration results and the dense tar mist is almost entirely dissipated, leaving a relatively few large tar drops in its place. This rather figurative description will seem more real to those who have witnessed this remarkable phenomenon within a glass vessel filled with dense fumes or fog. The instant the current is turned on, the whole field can be seen to clarify. The commercial importance of this becomes

more apparent when we realize that this action can be brought about at almost any desired temperature.

"No attempt is made to free the gas of these agglomerated tar particles while it is still in the ionizing field. The apparatus is so arranged that everything is swept on through into some form of mechanical extractor where a complete removal is affected with very little power loss. The Doherty Centrifugal Tar Extractor worked very well to accomplish this; the old type P and A machine also became a very efficient tar extractor when placed after the ionizer.

"The whole process may be summed up in this: It is practically impossible to free the gas from tar in the extremely fine state of subdivision which naturally results from rapid condensation. There is no difficulty in removing relatively large drops and the electrical treatment simply converts the fine mist into the large drops."

Enormous sums of money have been expended in attempting to perfect a commercial process, that is, a process which would deliver clean gas of uniform calorific power continuously. The great difficulty which has always been met, lies in the fact that the success of any gas-making process depends almost entirely, you might say, on the skill with which it is operated. Machines and processes may give perfect results in the hands of the inventors or skilled operators, but when they are sold promiscuously and are handled by unskilled or indifferent operators, the result is failure. This has been the history of the gas producer development for years past, with the result that all clean gas producer development work is looked upon with a great deal of suspicion.

Let us confine our attention to the application of clean, cold producer gas to some of the heating operations which are generally done with other fuels, such as oil, for example. We will first run over, briefly, the types of furnaces which may be adapted to the use of producer gas. These can best be discussed under the following headings:

Double Regenerator.

Single Regenerator.

Double Recuperator.

Single Recuperator.

Combination Regenerator and Recuperator.

Simple furnace where no waste heat is recovered.

For the purposes of this discussion, we will define regeneration as a reversing process, in which the gas or air, or both, to be heated, is first brought in contact with heated surfaces, usually checkerwork, which, in the previous cycle, has been heated by being in contact with the heated products of combustion leaving the furnace. This is the old Siemens process with which you are all familiar.

We will speak of recuperation as the non-reversing process where the products of combustion give up their heat to the incoming gas and air by conduction and radiation through the flue walls. The incoming and outgoing gases are always kept in separate flues.

It is possible to obtain a higher furnace efficiency with producer gas firing and double regeneration than it is possible to obtain with oil. The reason for this possible high efficiency is that the sensible heat of the products of combustion is just about equal to the quantity of heat required to raise the gas and air for combustion to the same temperature as the products of combustion leaving the hearth.

To illustrate—assume a double regenerative furnace working with a hearth temperature of 1650 deg. Fahr. There will be enough heat in the products of combustion to raise the temperature of the incoming gas and air to 1650 deg. Fahr. at the top of the regenerators.

When burning oil, on the other hand, double regen-

eration obviously is impossible. The sensible heat of the products of combustion is greatly in excess of the heat required to raise the air to the temperature of the products of combustion, and very little heat can be taken up by the oil. The balance of the sensible heat from the products of combustion must necessarily be wasted.

Double regeneration with coal gas is not advisable. The hydrocarbon vapors carried in the gas, when brought in contact with the hot checkerwork, are cracked to hydrogen and carbon, the carbon being deposited as soot in the checkerwork. We can see no reason why single regeneration cannot be used with considerable saving, but have no experimental data on this possibility.

Generally speaking, it will not be practicable to build regenerators which would bring about a perfect transfer of heat. In order to demonstrate how far heat recovery could be carried, however, we built an experimental furnace in which the products of combustion leaving the bottom of the regenerators were kept within from 10 to 15 deg. of the temperature of the incoming gas and air. During the test which was run for two days, the products of combustion leaving the furnace were at no time above 85 deg. Fahr. This, of course, was not commercially practicable, as the cost of such a complete saving of the heat was more than the heat was worth. The average stack temperatures of our commercial furnaces are around 175 deg. Fahr., very rarely going over 200 deg. Fahr. We might say that in all of our work, we have found that it is a comparatively simple matter to build apparatus which will save heat, but it is a real achievement to build apparatus that will save heat and money at the same time.

It will be noted that the above discussion applies only to the double regenerative furnace. When firing with producer gas, and using only single regenerators, there must necessarily be a loss of approximately 40 per cent of the sensible heat of the products of combustion leaving the hearth, which are wasted to the stack.

To illustrate the possibilities of producer gas firing, we will describe a set of furnaces which we have designed and built for the Ford Motor Company at Detroit, for heat-treating front axles. Three heat treats are required. After the first heating, the axles are allowed to cool in the air by radiation. After the second heating, they are quenched. After which they are again heated to a lower temperature and allowed to air cool. These furnaces are so designed and laid out that the axles are pushed mechanically through the first furnace and kept moving for a space of about 10 ft., until they reach a temperature within 50 deg. of room temperature. They are then mechanically fed into the second furnace, pushed through and quenched. A conveyor carries them from the quenching tank to the feeding mechanism of the third furnace, where they receive their final heating and are pushed out the rear end ready for the machine operations. It will be noted that the axles are handled mechanically throughout the process, and after being fed into the first furnace, do not stop until the three heat treating operations are complete. These three furnaces have a capacity of completely heating one front axle per minute. Although the heats are different in each furnace, the three furnaces are duplicates, with the exception of the draft and damper settings to bring about the required temperatures. We will describe more in detail one of these units.

The hearth is 5 ft. wide by 14 ft. long. The axles are placed on especially designed cast-iron ways with the forks hanging down. When the furnace is filled with these axles, the axles themselves form a practically solid floor which moves along through the fur-

nace over the ways. Small pieces, such as camshafts, spiders, spindles, etc., are piled on top of the axles and are carried through the furnace, receiving exactly the same heat treatment as the axles. These small parts are handled by hand between each furnace, as no mechanism has, so far, been designed to handle them mechanically. The gas and air are delivered through the reversing valves to the regenerators at a pressure of approximately 3 in. of water. The four regenerators are placed directly under the hearth. The gas on the inside and the air on the outside. There is one combustion chamber immediately over each pair of regenerators and immediately under one-half of the hearth and extending under its entire length. The products of combustion pass through flues along the sides of the hearth, sweep over the hearth, down through the flues on the opposite side, divide after passing through the opposite combustion chamber, and down through the opposite pair of regenerators, through the reversing valves and out the stack. The furnace is reversed on an average of every 15 to 20 minutes. The products of combustion, while passing over the hearth, are directed by a series of jack arches placed every 2 ft. at right angles to the movement of material over the furnace hearth. A solid division wall, built from the foundation to the hearth, separates the two pairs of regenerators. The furnace is enclosed in a steel jacket with $2\frac{1}{2}$ in. of insulating material between steel and brick work.

We might mention that we have built this type of furnace with a muffle to prevent the products of combustion from coming in contact with the steel, the idea of the muffle being to reduce the scaling to a minimum. After several months of comparative tests in running these furnaces with and without the muffle, we concluded that the benefits from the muffle did not warrant the additional expense in construction and operating cost. To maintain an average hearth temperature of 1650 deg., it was found necessary to keep an average temperature in the combustion chamber of 2550 deg. outside the muffle. The average gas consumption was 264 cu. ft. of gas per minute, the average cubic feet of gas per ton of stock being 22,970. The efficiency of the furnace was $14\frac{1}{2}$ per cent.

With the same type of furnace, running under exactly the same temperature conditions and delivering the same amount of stock, without the muffle, that is, the products of combustion coming in contact with the steel, we find that the average gas consumption was 73 cu. ft. of gas per minute, or 11,500 cu. ft. of gas per ton of stock, with a furnace efficiency of 26 per cent, as compared with $14\frac{1}{2}$ per cent, as stated above.

By furnace efficiency, we mean the total amount of heat put into the stock, divided by the total amount of heat delivered to the furnace in the gas.

From the above comparisons, it will be seen that the cost of operating, which will be discussed later, is very much greater when the muffle is used and the practical results on this kind of stock, with skillful operation, are about the same in both cases. We, therefore, conclude that for this type of work the muffle is not warranted. The muffle furnace, we feel, is not at all practicable unless double regeneration is used, as the heat losses would become enormous without efficient waste heat recovery. With double regeneration, however, it will be observed, even with the muffle furnace, a furnace efficiency is possible which is very much in excess of the ordinary oil-fired furnace, which rarely exceeds 10 per cent in efficiency.

We find that the temperature of the stock heated in the furnace can easily be kept within a variation of 10 or 15 deg. By skillful operation, there is no difficulty in keeping the temperature variation within 5

deg. These results have been obtained over tests of several months' duration.

It may be interesting to note that the Ford Motor Company is now adding six additional front axle heat-treating units of the Steere Company design, which will probably be in operation by the first of July.

At the time of writing this paper, we have not completed the work which has been going on for over two years, of developing a furnace to replace oil for drop forging work.

We now have about completed a double regenerative type forge furnace enclosed in a metal case, which will be thoroughly tested out within the next thirty days, but unfortunately, no data are yet available on this particular construction.

It might be interesting, however, to note the data which were taken on a forge furnace which we built and operated for several months on regular production. This furnace was of the recuperative type with metal recuperators. The hearth was 4 ft. wide by 2 ft. deep. The stock heated was 2-in. round bars. Parts weighing 3.88 lb. each were made from the heated bars in an upsetting machine.

One hour and 15 minutes were required to bring the temperature of the furnace from cold up to forging temperature. When the furnace was filled with stock, from 15 to 20 minutes were required to bring the stock to forging temperature. The furnace was run at a capacity of 318 lb. of stock per hour. The temperature of the stock varied from 1850 deg. to 1950 deg. Fahr. The temperature of the hearth varied from 2300 deg. to 2400 deg. Fahr. On an average, a differential of 500 deg. was maintained between the stock and the hearth temperature.

The average of several tests was found to give a fuel cost of \$2.00 per ton of stock heated.

The furnace was operated by putting ten cold bars into the furnace at a time. This naturally lowered the temperature of the furnace, which, as stated above, required from 15 to 20 minutes to bring this stock up to forging temperature. After the stock had been brought up to furnace temperature there was a surplus of heat available and considerable care had to be exercised that the stock was not overheated.

It was found that better work could be done with this furnace than was done with the old furnace, because it was impossible to heat the stock too rapidly, that is, the core and outside of the bar were at practically the same temperature. Also the absence of smoke and dirt made the furnace much more desirable.

The above data were taken on one of the several forge furnaces of different types with which we have been experimenting. We feel that there is absolutely no question that producer gas can be successfully used on all forging operations.

ADVANTAGES OF REGENERATION VERSUS RECUPERATION

With properly designed regenerators, it is possible to recover a much higher percentage of the heat of the waste gases than is possible with recuperators, unless recuperators of very elaborate design are built. Recuperators may be built of metal or refractory material. The advantages of metal recuperators are in preventing leakages and short-circuiting. The disadvantages are in their very rapid deterioration, especially at higher temperatures. The disadvantages of regenerators, on the other hand, are that the regenerators must be reversed at intervals of approximately 20 minutes to half an hour, which requires additional mechanism and operating complications. The evidence which we have accumulated to date, however, is distinctly in favor of regeneration and against recuperation, as we have been unable to secure refractories

which have the proper heat conductivity, and at the same time can be kept tight through the wide range of temperatures under which they have to operate.

We find that the expense of a furnace with the stock handled mechanically over the hearth, is not justified unless large quantities of stock of the same kind are to be heated. Also if the heating operations are run continuously for a good many hours, the extra expense of the mechanical furnace is not warranted.

Each particular problem, however, must be studied by itself, as it is impossible to lay down anything more than the most general rules. In a continuous mechanical furnace, such as the front-axle furnace above described, where one axle is charged and one discharged every minute, the front and rear doors must necessarily be open. This, of course, results in quite a loss of heat from the hearth. Intermittent furnaces, built with one door which can be kept closed during the heating operation, show higher fuel economy than furnaces open at both ends.

We have built furnaces similar in principle to the front-axle furnace described above, for use in annealing steel for stamping work where the material was maintained at 1650 deg. Fahr. The costs for this work were practically the same as for the 1650 deg. Fahr. heat treat on front axles, that is 40c. to 45c. per ton. This type of furnace has also been built for carbonizing gears.

We have also applied producer gas with entire success in brazing and for heating enameling ovens.

COST OF GAS

The cost of producer gas necessarily varies with the price of coal, water, labor, investment in plant, hours operated daily, etc. The labor and capital charge varies also with the size of the plant. For example, take a plant with a capacity of 3,000,000 cu. ft. of gas per 24 hours, with coal at \$3.00 per ton, producer gas will cost 4 $\frac{1}{2}$ c. per 1000 cu. ft. A plant with a capacity of 15,000,000 cu. ft. per 24 hours, and coal at \$3.00 per ton, the gas would cost 4 $\frac{1}{4}$ c. per 1000 cu. ft. On a B.t.u. basis, this corresponds to 4 $\frac{3}{4}$ c. and 4 $\frac{1}{4}$ c. oil, respectively. It must be kept distinctly in mind, however, that these figures are costs of the fuel delivered to the furnace and do not take into account capital charges of the distribution systems necessary, capital charges on the furnace investment, repair of furnaces, etc. In other words, it is the total cost of the fuel ready for distribution, rather than the cost of heating stock.

The following data are the result of continuous tests taken on the above described front-axle furnace from April 1 to April 20:

Output of furnace, tons per hour.....	0.781
Cubic feet of gas per hour.....	9,000
Cubic feet of gas per ton of stock.....	11,500
Calorific power of gas B.t.u. per cubic feet.....	127
Cost of fuel per ton of metal (gas at 3 $\frac{1}{2}$ cents per M) $\frac{1}{2}$	\$0.401
Cubic feet of gas per minute for "furnace standing by".....	73
Cost per hour for fuel for "furnace standing by" with gas at 3 $\frac{1}{2}$ cents per M cubic feet.....	\$0.154
Pounds of stock per hour per square foot of floor space.....	9.1
Per cent of total heat supplied furnace into stock that is, efficiency of furnace.....	26
Per cent of total heat supplied furnace to stock.....	8
Per cent of total heat supplied furnace to radiation.....	66

In the above test the fuel supplied the furnace was measured by means of a station meter. This meter measured the gas supplied to two furnaces, the gas being divided between the two furnaces by means of Pitot tubes installed on both furnaces.

The amount of heat that went into the stock was determined from the rise in temperature of the stock, and its specific heat. This specific heat was determined by laboratory experiment and found to be 0.12.

In the above data, special attention is called to the calorific power of the gas, which is only 127 B.t.u. per cubic foot. The reason for this low B.t.u. is that the gas was made by gasifying pea coke. This also accounts for the low cost of the gas per thousand cubic feet. This gas would be equivalent to ordinary producer gas at 4c. per thousand cubic feet.

This particular test has been selected out of a great many run to show that a very weak gas can be effectively used in a properly designed furnace, which is contrary to the general opinion that a weak gas cannot be effectively used. The results of these tests check very closely with the average of a long series of tests on gases of difficult calorific power.

Independently of ours, tests were run on the same furnace over an extended period, and at the same time tests were run on an oil-fired furnace to determine the comparative fuel costs of the two methods of heating. The results of these tests, which were made independently of our tests, showed that the cost of producer gas per ton of steel was 44½ cents, as against the cost of oil at \$1.48, approximately 3 to 1 in favor of producer gas.

It should be noted again that this cost only applies to the cost of the fuel at the furnace.

We do not pretend to be able to give any costs of heating material with oil. We have run a good many tests and have the results of a great many tests, but there is such a tremendous variation that we prefer to use the figures on oil given us by our clients. We have found that in most cases the tests that were run to determine the costs of heating with oil are run over altogether too short a period. In the work we have done along this line, there have been enormous variations in the quantity used from hour to hour, which leads us to believe that the only way to arrive at a safe estimate is to run the test over a very long period. All of our producer gas data have been taken over a period of at least two weeks, and in most cases are run for two or three months.

In considering the substitution of producer gas for oil, some of the following points should be given most careful consideration. In general, producer gas is not to be considered on small installations. Local conditions and the future price of oil determine when a producer gas plant is or is not advisable. A producer gas plant should be run twenty-four hours a day to realize the best commercial results. It must be also borne in mind that the manufacturing of producer gas is a highly specialized industry in itself, and any concern figuring on adopting this fuel must accept the responsibility of running an entirely separate industry. Also it is difficult to obtain producer gas operators, as there are comparatively few plants running at the present time where men are trained in this kind of work. One of the solutions for this phase of the problem is to build central producer gas plants which will distribute gas to several concerns, having the producer gas plant a separate organization, selling gas to these various concerns the same as the ordinary city gas plant distributes gas.

Plant managers and superintendents must also keep in mind that a radical substitution of fuels must necessarily change their operations to some extent. We have found that it is at first quite difficult to get men who have been accustomed to using oil to change to producer gas, especially if they are working on piece work. After becoming accustomed to gas, however, they prefer it. As has been pointed out above, radical furnace changes are also necessary if the best results from producer gas are to be obtained. In this connection it may be interesting to note that we have in several cases changed over existing oil furnaces to producer gas fur-

naces with entirely satisfactory results as far as heating was concerned. The cost of the gas, however, was necessarily high because of the inefficient use of the gas. The results to date on this kind of work have indicated that the ordinary oil furnace, with a very small expense, can be converted to a producer gas furnace and operated at a cost corresponding to about 6 cents to 7 cents oil.

Briefly, the advantages of producer gas may be summed up as follows:

It furnishes a dependable fuel supply under your own control—that is, it is as dependable as coal.

It can be used for all classes of heating work, including enameling.

The flame temperature being low and the gas volume large, there are no intensely hot spots in the furnace, with the result that repairs on brick work are next to nothing.

The highest furnace efficiencies are possible with gas.

In every application that we have studied we have found that the costs were less with producer gas than with oil.

More uniform heating of the stock, and more accurate control of temperatures were possible.

Last, but not least, every gallon of oil that automobile men use in making cars leaves that much less oil for making gasoline to run them with. Automobile manufacturers, above all manufacturers, should discourage the use of oil for everything outside of making gasoline. The present high price of gasoline, as well as the high price of fuel oil, can be traced back in large part to the tremendous quantities of crude oil that are consumed by manufacturers of automobiles and their accessories.

In conclusion, we call your attention to the fact that practically all of the work which we have done to date has been done while production was in full swing. A great number of practical problems have presented themselves, which it was necessary to overcome in order that production would not cease while the experimental work was in progress.

Also it must be kept in mind that the application of clean producer gas to industrial heating operations may be considered as an infant industry. From our observations to date, however, we feel that the infant is rapidly growing and that the future of this fuel is assured.

Course in Laboratory Organization.—A course on Laboratory Organization and Management is offered in connection with the summer session at Columbia University by Prof. Thomas B. Freas and Prof. W. L. Estabrooke. This course is unique in character and content. It is planned to take the students' full time for six weeks. The subjects carried will be: location, laboratory construction, ventilation, etc., of buildings; laboratory equipment, including desks, lockers, shops, gas, electricity, water, suction, liquid and compressed air, balances, etc.; buying from foreign and domestic markets, economic and scientific handling of supplies; organization of stockroom employees and their co-operation with the teaching staff; glass blowing by a professional glass blower will be a special feature; a series of trips in and about New York to manufacturing establishments, industrial and university laboratories, including trips to Boston, Washington, D. C., Niagara Falls, Buffalo, Rochester, Syracuse and Philadelphia, in which there will be opportunity to observe actual application of chemistry to needs of the country from the most modern viewpoint; and especially to the needs of university, college and industrial research laboratories in order to meet the demands of modern chemistry.

Recent Developments in the By-Product Coking Industry of Japan

By T. Kurahashi

In Japan, especially at Kyushu, Osaka, and Tokyo, there are many coke plants, but most are beehive ovens. There are by-product ovens, however, at the following places:

1. Tokyo Gas Light Company, Ltd., Tokyo.
 2. Osaka Seimi Company, Ltd., Osaka.
 3. Mitsubishi Makiyama Coke Plant, Tobata, Fukuoka.
 4. Imperial Steel Works, Yawata, Fukuoka.
 5. Miike Colliery, Omuta, Fukuoka.
- Of these the Imperial Steel Works and the Miike Colliery are most important.

The Tokyo Gas Light Company, the oldest and biggest gas company in Japan, has several gas works around the metropolis, namely, Semju, Fukagawa, Oshima, Shiba, Sunamura, Omori, and the Fukagawa tar products works. Of the gas works, the first four are operated with retorts, while the last two, Sunamura and Omori, have by-product ovens. The Sunamura plant has two batteries, one of 18 Koppers regenerative ovens, the other of 15 of the Semet-Solvay type. The Omori plant has one battery composed of 10 Koppers recuperative ovens. Both works recover by-products—tar, ammonium sulphate, and also benzol from the Semet-Solvay ovens. From the Koppers plants, the surplus gas is used for illuminating purposes so that the benzol cannot be recovered, because it is an important illuminating component in the gas. On the other hand, tar and other by-products in the crude state are shipped in small tank boats to the Fukagawa Tar Product Works, and treated so as to produce various dyestuffs, medicines, and other high-grade coal-tar distillation products. The coke is sold for foundries and metallurgical plants, and the breeze for fuel for limekilns.

The Osaka Seimi Company, Ltd., Osaka City, is one of the oldest coke by-product recovery plants in the Japanese Empire, and its former chief engineer, Dr. K. Shimomura, who is the foremost authority on the coke industry in Japan, contracted with the Semet-Solvay Company about twenty years ago, to build one battery of 10 Solvay-type ovens, thus founding the first by-product coke oven plant in Japan.

Now the company has two batteries of the same type, with tar, ammonium sulphate, naphthalene and benzol recovery plants and dyestuff factory. But last year the dyestuff factory was transferred to the Japanese Dyestuff Manufacturing Company, Ltd., with the similar plant of the Osaka Gas Light Company, Ltd., and hereafter Dr. Shimomura will be the chief engineer of the new company.

The northeastern Kyushu, famous as a coal field and on account of its recent industrial growth, is

important for the coke industry. It contains three by-product coking plants as follows:

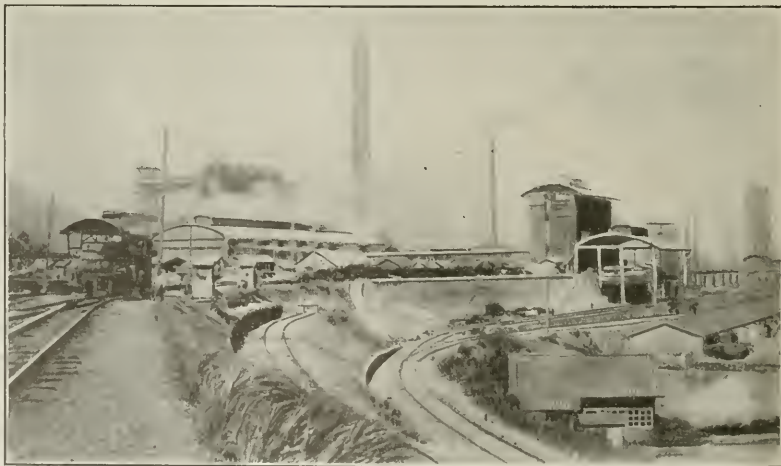
The Mitsubishi Makiyama Coke Mfg. Company was established in 1910, to supply the blast furnace coke to the Imperial Steel Works, and it was originally operated with beehive ovens. But now it has two batteries of Semet-Solvay by-product ovens, one of 25 ovens, the other of 10 ovens, besides 50 beehive ovens. Tar, crude naphthalene, and benzol are recovered.

One of the interesting features of the plant is that ammonia liquor and surplus gas are supplied to the Asahi Glass Mfg. Company, Ltd., the biggest and only window glass factory with the American mechanical blowing system in Japan, and there the surplus gas is used as fuel in the glass making. Ammonia liquor is also furnished to the Am-Solvay Process Soda Manufacturing plant, which belongs to the glass company.

The Imperial Steel Works, the most distinguished steel and iron works in the Orient, have coke plants for the blast furnaces. They were formerly beehive ovens of the Coppee type, but are now by-product ovens of the Semet-Solvay and Koppers types. The Semet-Solvay plant comprising 150 ovens, arranged in six batteries of 25 each, each oven having a capacity of 6 to 7 tons of coal, had been built up in 1907-8; on the other hand, the Koppers type, comprising one battery of 120 ovens, each of 7 tons capacity, were begun in 1914. Tar, ammonium sulphate, naphthalene, and benzol recovery plants are in operation, and the benzol is supplied to the Japanese Dyestuff Manufacturing Company.

In this connection, I will mention the results obtained in experiments on the utilization of coke-oven waste heat for steam raising with the Babcock & Wilcox multi-tubular boilers by the engineers of the Steel Works. The waste heat from one battery of the Semet-Solvay ovens which carbonize 100 tons of coal per day, can raise 45.6 tons of 8 atmospheric pressure steam per day, that is, 456 kg. per ton of coal per day; on the other hand, the surplus gas from the ovens can raise 580.8 kg. of steam per ton of coal carbonized, thus we have a total of 1036.8 tons of steam per battery per day. The steam, of course, is used for steam engines in the central power station of the works.

It is said that the Steel Works had decided to contract for any new type of coke oven of recent enlargement, and it will apparently contract with some American by-product coke oven builder as yet undecided.



WHOLE VIEW OF COKE PLANT, IMPERIAL STEEL WORKS, YAWATA, FUKUOKA

The Miike Colliery, the largest colliery in Japan, which belongs to the Mitsui Mining Company, Ltd., Tokyo, has the most improved 122 Koppers regenerative ovens in four batteries (in which is No. 4 battery just put in operation), each oven of 8 tons capacity; the coal carbonized amounts to about 120 tons per battery per day. Plants for the recovery of tar, ammonium sulphate (Koppers direct process), naphthalene, anthracene, and benzol, and also for the manufacture of dyestuffs are provided. Of these, alizarine dyestuffs produced from the anthracene are the only ones successfully made in Japan. The gas produced amounted in 1916 to 3,600,000 cu. ft. per day (from three batteries) of which 1,800,000 cu. ft. were used for the coking, 1,200,000 cu. ft. for the two gas engines, each of 3,000 hp. (one is spare), the surplus for boilers, zinc furnaces, etc., and finally a part for delivery to the city for the use of the Omuta Gas Light Company, Ltd.

According to news which I received a few days ago from Tokyo, it would seem to be a fact that the works are engaged in research on a type of new coke plant that will be built in parallel with the present Koppers ovens, and that the works will select some new type, now being improved in the United States of America.

The South Manchurian Railway Company, Ltd., has decided to adopt the Roberts type of oven for the coke plant which will belong to the An Shan Chan Steel Works in South Manchuria, and the company has contracted with the American Coal and By-product Coke Company of Chicago, Ill., about the new coke and its by-product plants. The annual output of coke is said to be about 150,000 net tons.

The coal used in present practice in the works mentioned above is as follows:

	Ash	Vol. Mat.	Fixed Carbon	Sulphur	Locality
Bujun	7.53	50.36	42.11	0.71	Manchuria
Miike	14.85	40.23	44.92	3.92	Kyushu
Takashima ...	8.58	37.15	54.27	0.95	Kyushu
Honkeiko	20.54	21.52	57.94	0.143	Manchuria
Kaihei	14.70	31.70	53.60	1.183	Manchuria
Amakusa	10.92	17.20	71.88	0.976	Kyushu

Among them, "Takashima" produces good coke, low in ash and sulphur, high in calorific power and moderate in coking power, but a little high in phosphorus.

"Miike" is famous too, of high calorific power, moderate caking power, rich in by-products, but one defect is its high sulphur content.

"Honkeiko," low in sulphur, phosphorus, and volatile materials, produces good coke, but it is unsuitable for use in the blast furnace because of its high percentage of ash and also its high melting point. "Kaihei," "Sakito," "Futase," "Amakusa," are good too.

With respect to the by-product coke industry, there is a great question as to the future of the dyestuff manufacture in Japan. The importations of dyestuffs into Japan, almost all of them from Germany, were as follows (1 yen = \$0.50):

	Synthetic Indigo	Other Coal-tar Dyes
1913.....	Yen 1,879,967	4,154,658
1914.....	3,277,362	4,485,691
1915.....	.....	.....
1916.....	123	2,385,526

This shows that the annual importations amounted to about 7 or 8 million yens, that is nearly 3.5 or 4 million dollars. But since the beginning of the great war, importations have been cut off, and the shortage of the stock has brought about an unnatural rise in their prices. Under these circumstances, many consumers have turned their attention to the possibilities of home supply.

Japan has 40 color works now, but many of them being on a very small scale are unsuitable for that kind of industry. The few which follow are the exception:

1. Tokyo Gas Light Company, Ltd., Tokyo.
2. Japanese Dyestuff Manufacturing Company, Ltd., Osaka.
3. Yura Dyestuff Manufacturing Company, Ltd., Wakayama.
4. Miike Colliery Omuta, Fukuoka.

In my opinion, it would be better for Japan to have one or two large works (say one in Osaka and the other in Kyushu) instead of forty or more little works. When peace comes, I am afraid that the small works will suffer and many of them be forced to stop operation, but the excited Japanese manufacturers will not heed my advice, and I fear that time will prove the correctness of my opinion.*

*The author of this article is at present in this country and will be glad to answer inquiries concerning the above subject or other chemical and metallurgical industries in Japan. His address is care of Japanese Consul General, New York City.

Potash from Cement at the Riverside Portland Cement Company

In our June 1 issue, page 653, we gave a short description of the work being carried on in the recovery of potash at the plant of the Riverside Portland Cement Company, Riverside, Cal. We are indebted to Mr. John Treanor, manager of the company for the following additional data.

GENERAL CONSIDERATIONS

This company is now recovering 6 lb. of potassium sulphate for every barrel of clinker burned. This quantity at present price is worth from 40 to 50 cents per barrel of cement produced. On the pre-war basis the same material would have a value of about 18 cents

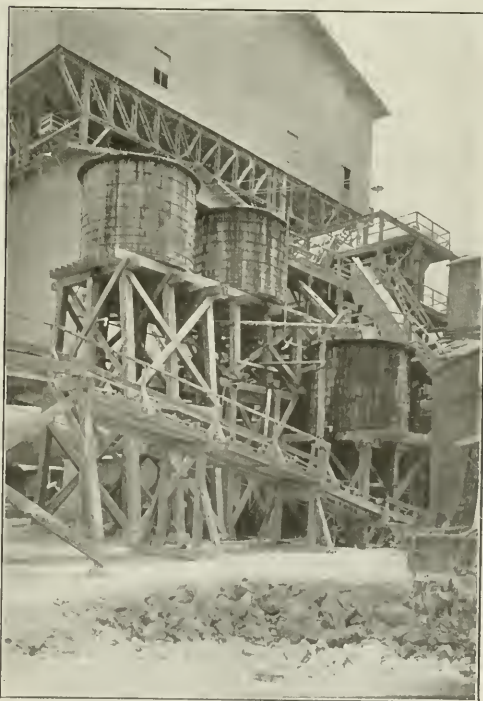


FIG. 1—HOT WATER AND MIXING TANKS AND BELT DIS-POSING OF FILTER CAKE

per barrel, a figure which would still leave a very attractive net profit.

Clays and shale suitable for Portland cement manufacture vary in K_2O content up to values as high as 2½ per cent. During the past year many Portland cement raw mixtures from Eastern manufacturers which were examined in the Riverside laboratories were found to contain from 0.8 to 1.25 per cent of K_2O .

In the ordinary burning of Portland cement raw mix, from 40 to 50 per cent of the potash content is volatilized and leaves the kiln with the kiln dust. This volatilized potash can be recovered in the form of a more or less dilute salt by the installation of suitable dust collecting systems.

The amount of potash recovered depends upon the efficiency of the collecting devices. The efficiency of the Cottrell electrical precipitators varies from kiln to kiln; the best individual kilns giving results as high as 80 per cent of the potash volatilized, while individual treaters over other kilns have an efficiency as low as 55 per cent. A 100-ft. rotary kiln, for example, may produce anywhere from 4 to 7 tons of dust daily, whose average potash content may range between 4 and 10 per cent. The Western Precipitation Company worked out the problems of electrostatic precipitation.

The potash contained in this dust is usually water soluble, or if part is insoluble it will be amenable to further chemical treatment. This potash containing dust recovered from the kiln gases can be sold as dilute fertilizer just as it is. Such a by-product is regularly being produced by the Security Portland Cement Company at Hagerstown, Md., and by the Alpha Portland Cement Company at its plant on the Hudson River.

The use of this dust, however, is restricted to agricultural operations requiring a lime base fertilizer. It cannot be conveniently used as an ingredient for a complete fertilizer on account of its dilute form. The cost of freight upon 90 per cent of inert material is burdensome, reduces the net selling price, and limits the available market. The usual requirement for complete fertilization work is a salt whose K_2O content is not under 35 per cent, and it is toward this ideal that efforts have been directed in striving for a process for recovering potash from cement plants.

The potash recoverable from all cement kilns under all conditions will be in the form of potassium sulphate. During the past five years the laboratories at Riverside have been working on the problem of deriving a more concentrated salt from this dust. One of the obstacles, however, was that only 50 to 55 per cent of the total K_2O originally present in the dust could be extracted in water soluble form.

Recently it has been discovered that the cause of this

poor extraction was the formation of a double salt of potassium and calcium sulphate which at ordinary temperatures has a low degree of solubility. This double salt is the mineral syngenite, occurring in nature. Knowing the cause of the poor extraction it was but a step further to remedy it, and it was finally found that by keeping the mixture at a minimum temperature of 85 deg. C. during the leaching and filtering process, and maintaining proper conditions of concentration, all of the water soluble potash originally present in the dust could be recovered. A patent (No. 1,220,989) based upon this simple fact has been obtained.

CALCIUM FLUORIDE PROCESS

For every 1 per cent of K_2O in the raw mixture it would be theoretically possible with this process to recover 6 lb. of K_2O from each barrel of clinker, providing the volatilization is complete. Upon the pre-war basis of 3 cents per pound, this would amount to 18 cents per barrel, so that any economical means by which a better volatilization of K_2O from the clinker could be accomplished would be decidedly worth while. Working toward this end a process was developed (patent No. 1,194,344) which makes use of calcium fluoride as a reagent for increasing the volatilization of potassium salts from the clinker and the regeneration of the reagent from the dust collected. This is accomplished as follows:

For every 1 per cent of K_2O present in the raw mix, approximately 0.8 per cent of calcium fluoride is added. This addition permits the formation of potassium fluoride, which is readily volatile and has a boiling point of about 850 deg. C. The reaction between the calcium fluoride and the potash in the raw mix, however, does not take place until a temperature of about 1100 deg. C. is reached. At this temperature, which is far in excess of its boiling point, the salt will be rapidly expelled from the raw mixture and carried off with the gases of combustion and the dust.

This volatilized potassium fluoride, however, does not persist in this form. It is more or less completely converted by the oxides of sulphur in the gases of combustion to potassium sulphate. This transformation is accompanied by the liberation of hydrofluoric acid, which is immediately neutralized by the lime compounds in the dust and is converted into calcium fluoride. This dust is then leached by the process already described and the soluble potassium sulphate separated from the insoluble calcareous and argillaceous material by filtration.

The filter cake obtained by this operation is a useful raw mix containing in addition to cement making substances all of the calcium fluoride originally used, and



FIG. 2—EVAPORATING PONDS, AND POTASH PLANT



FIG. 3—EVAPORATING PANS, "COOKERS"

in addition to this the deleterious constituent, lime sulphate.

Originally it was attempted to enrich the dust by re-burning it, and although this gave a very rich potash dust, the operation was extremely uneconomical. In fact, only 20 per cent of the total potash fed into the kiln in the shape of stack dust and treater dust was volatilized. The remainder, or 80 per cent, was driven into the clinker.

The cause of this was found to be the calcium sulphate present in the dust. In the presence of fluoride, however, the calcium sulphate decomposes, which discovery was embodied in patent No. 1,219,315. This reaction then makes it possible to again return the filter cake containing among other things the calcium fluoride to the raw mix where the calcium fluoride again performs its function of increasing the volatilization of the potash in the raw mix. By this cyclic process the volatilization at the Riverside plant was increased from 60 to 90 per cent.

Summing up the possibilities of recovery of potash as a by-product in Portland cement manufacture, the experience at the Riverside plant indicates that 90 per cent of the potash contained in the raw mix can be volatilized; 10 per cent remaining in the clinker. Eighty per cent of the potash so volatilized in the kiln should be caught by the dust collectors. The net product, about 70 per cent of the original input, will be still further reduced about 5 per cent by losses in filtering. It has been demonstrated by the work at Riverside that it is entirely conservative to look for the recovery, in the form of concentrated salt, of 66 2/3 per cent of the potash originally contained in the raw cement mix, and it is quite possible that even these results may be

improved upon by increase in the efficiency of the dust collectors. The resultant salt is received most enthusiastically by the fertilizer trade.

MECHANICAL FEATURES OF THE PROCESS

The dust is drawn from bins under the electrical treaters into tanks where it is put into solution by agitation in water of not less than 85 deg. C. at a concentration of not over 5 per cent K_2O . The apparatus consists merely of cylindrical tanks some 12 ft. in diameter and 8 ft. high, which have on their axis a vertical shaft carrying ordinary propellers. The tanks are filled with water to a depth of about 6 ft. and the water brought up to the desired temperature by means of steam injected into it. Fig. 1 shows two hot-water storage tanks on the left and one of the agitator or mixing tanks on the right. There are three of these mixing tanks, each delivering a batch every fifty minutes. The dust is then charged into this heated water and the temperature rapidly rises to boiling point, due to the hydration of the lime contained in the dust. Samples are taken every few minutes, filtered, and specific gravity determined as well as percentage of solids. The potash goes into solution surprisingly fast under the conditions described. The whole operation of extracting the water soluble potash from 7 tons of dust is accomplished in less than fifty minutes, and the whole control has reduced itself to a very simple basis.

As soon as a batch is cooked in one of the tanks it is run by gravity into the filter reservoir under an Oliver filter press, where its temperature is maintained by steam coils, and the whole is kept at a homogeneous consistency by means of an agitator. The suction of the filter drum then forms a cake, and as the drum revolves this cake emerges from the pulp and encounters a bank of hot water sprays. Suction is applied automatically after passing this point to remove as much water as possible from the cake, which, when it reaches the horizontal position of the floor level, is scraped off by means of a plow.

The solution thus extracted from the cake is passed directly to storage tanks (Fig. 2), which are at the same time settling and evaporating ponds by means of solar evaporation, which is very active in the dry climate of southern California. When the liquid has attained a specific gravity of about 1.1 per cent it is pumped to the evaporating pans (Fig. 3), where the liquid level is maintained at a fixed point and the solution becomes more and more concentrated and the salt drops to the bottom. The company has five of these pans installed. It is then raked out upon a drain board, where it is allowed to remain some minutes, and thence is deposited in a hopper, where draining continues for several hours (Fig. 4). From this hopper it is passed through a rotary dryer, thence through a William's mill, where it is reduced to the desired fineness, and finally the salt proceeds to a bin under the sacking machine.

Credit for the invention of the chemical processes employed belongs to Frederick W. Huber, chief chemist of the Riverside plant, and to his assistant, Frank F. Reath.

Manufacture of Calcium Carbide in Brazil.—According to the annual report of the Companhia Brasileira Carbureto de Calcio, established in the city of Palmyra, State of Minas Geraes, the production of calcium carbide by this company during the year 1916 was 61,016 drums, as against 50,146 for the previous year. The board of managers calls attention to the fact that not only is the product well received in Brazil, but that considerable quantities have also been exported to the Argentine Republic.



FIG. 4—BINS WHERE WET SALT IS STORED TO DRAIN, ALSO ROTARY DRYER FEED

Synopsis of Recent Metallurgical and Chemical Literature

Switchboard for Experimental Work.—A description of a cheaply constructed laboratory switchboard, especially arranged to give great current flexibility, was given in a paper by W. L. BADGER at the recent Detroit meeting of the American Electrochemical Society. The board was built in the shops at the University of Michigan in 1915 and is used by the Chemical Engineering Department. It is stated to have cost a little over three hundred dollars. The transformer is rated at 10 kva. and is built for 230 volts on the high-tension side. The high-tension winding has five taps, so that low-tension voltages of 10 per cent above nominal, 5 per cent above nominal, nominal, 5 per cent below and 10 per cent below, may be obtained. On the low-tension side are two 10-volt coils and two 20-volt coils. The transformer was obtained from the Enterprise Electric Co., Warren, Ohio. A diagrammatic sketch of the wiring is shown in Fig. 1. The supply line is connected to a double-pole circuit breaker shown at the top of the board. This is provided with both overload and shunt release coils. From the breaker the current passes to the double-pole double-throw switch *I*, which connects the 220 volts either to the busbars direct, or to the high-tension side of the transformer through the three single-pole double-throw switches *E*, *F* and *G*. The five taps of the high-tension winding are connected to these as shown by the numerals. By suitable combinations of series, parallel or series-parallel connections, low-tension voltages, can be obtained of 60, 50, 40, 30, 20 or 10 volts at ratings of 100, 83, 67, 100, 100 and 33 per cent respectively. With any one of these arrangements the

voltage may be varied through five smaller steps by means of the switches *E*, *F*, and *G*, as shown above. The result is a very flexible arrangement, particularly suitable for granular carbon resistance furnaces where there is a wide range of resistance, as temperature changes. From the low-tension connections the current passes through the ammeter transformer and then to the furnace-room busbars.

Potash from Feldspar.—In the Canadian Chemical Journal, Vol. 1, No. 1, May, 1917, D. J. BENHAM, secretary of the National Potash Corporation of Toronto, describes a process used by this company in extracting potash from feldspar. The process was worked out by Allan Grauel of Kitchener, Ont., who was financially interested in a powder plant at the beginning of the war. The impossibility of securing the necessary potash for their operations induced him to devote his attention to the problem. The process, which is protected, consists in heating to a high temperature in a blast furnace, 110 tons of a mixture of feldspar, coal, calcium chloride and limestone. The limestone is used to render the slag fluid, while the chlorine of the calcium chloride combines with the potash, forming potassium chloride which distills over at the temperature of the blast furnace into a condenser where it meets a current of steam, in which it dissolves. By a process of evaporation and crystallization of the solution thus obtained, the salt is obtained in a high state of purity. It has been exhaustively tested out in the plant of the National Portland Cement Company, Ltd., at Durham, Ont. The success of the process is stated by the author to be in a large measure due to the earnest co-operation and assistance rendered by Mr. William Calder, formerly president and general manager of the plant at Durham, who unsparingly placed his extensive, modern equipment as well as his personal resources at the disposal of Mr. Grauel for the concluding experiments under commercial conditions.

It was found possible, with proper preparation of the charge, to drive off, under the most favorable conditions, over 90 per cent of the total potash content in the feldspar, which ranges from 8 to 14 per cent K₂O. The present percentage of collection of the vapors is not entirely satisfactory, however, and improvements are under way on this feature of the process. A satisfactory process for disposition of the soda vapors from the potash has also been developed. The mother liquor containing the potassium salts after being drawn off from the gas condensing and filtrating equipment is subjected to centrifugal treatment and evaporation. An evaporating pan, 12 x 60 ft. by 1 ft. deep being utilized. The gas treating equipment consists of a coil through which the volatilization products are collected and precipitated with steam. For the present only muriate of potash will be produced but satisfactory experiments have been conducted in the manufacture of caustic potash. It is of course also comparatively easy to produce chlorate from the chloride, but the entire manufacturing attention of the National Potash Corporation, Ltd., the company which has been organized to operate under Mr. Grauel's patents, will be concentrated on the production of muriate, which is so urgently required in the manufacture of explosives and for fertilizers for the great wheat, corn and cotton belts. Within a short time, however, the equipment for manufacturing caustic will be installed. The company expects to have its first unit with a capacity of 20 tons a day in active operation by the first of June.

It is stated to be possible to so adapt the process and the equipment as to utilize cement marl as a raw material instead of feldspar, where the latter is not readily obtainable, and it is also possible to utilize either rotary kilns or blast furnaces of a certain type for releasing

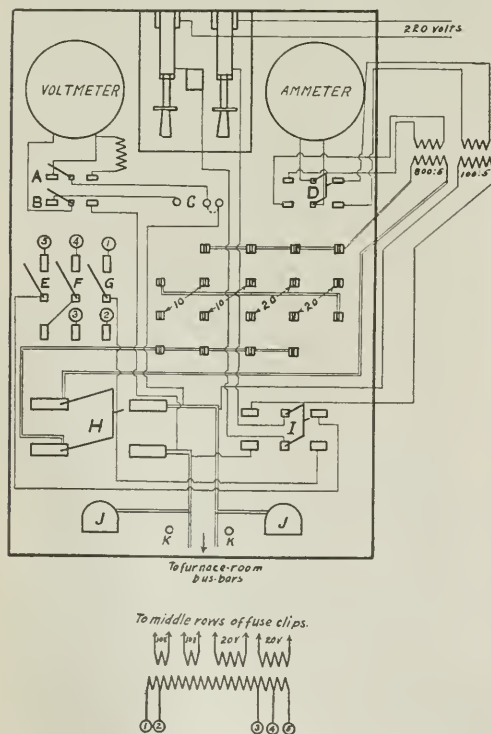


FIG. 1—TRANSFORMER BOARD FOR ELECTRIC FURNACES

the potassium fumes. In operating the blast furnace the slag is converted into sewer pipe, tile and paving brick, being poured direct from the furnace into the molds. It has a peculiar porcelain-like surface like all feldspar products. An interesting statement made in the article is as follows: "By their aid (the feldspar fields), the Canadian company will assuredly be able not only to break effectively the world-wide monopoly of Germany in potash production, but it should be able to capture and hold securely the whole American market if it treats the consumer fairly." There is, however, a peculiar feature connected with the burning of feldspar, for which no reason is yet revealed. This is the fact that all of the potash content does not volatilize at the same degree of temperature. A certain percentage is released at say 900 deg. C., more at 1000 deg, and so on until the last of it is finally driven off at about 1600 deg. This feature has presented grave difficulties.

Ferromanganese.—In the Journal of the Franklin Institute for May, 1917, ROBERT J. ANDERSON gives a review of the ferromanganese situation since the outbreak of the war. He points out that prior to the war we were the only steel producing country which did not produce its requirements of ferromanganese. Our steel manufacturers were obtaining cheap supplies from England and Germany and prior to 1914 the only company in this country manufacturing ferromanganese was the United States Steel Corporation. Since the war started, however, the manufacture of ferromanganese and spiegeleisen has been actively taken up and in 1916 we not only produced 75 per cent of our requirements, but both ferromanganese and spiegeleisen were exported to Canada, Italy, Sweden, Holland, Australia, etc. Most of the manganese ore for this production came from Brazil. Russia and India were formerly large exporters to other countries but these sources of supply were cut off and we have had to depend on Brazil for our manganese ore for making ferromanganese. Prices for ferromanganese in 1916 reached unheard of levels and the development of substitutes would be most acceptable to the steel producers. The author sums up his article as follows:

"It appears, in the light of the facts presented in the foregoing, that the manganese situation is one of serious importance—one that warrants thoughtful consideration on the part of those interested in the subject. The possibility of metallurgical science discovering a substitute deoxidizer which will take the place of manganese, either in whole or in part, appears to be an alluring one. Naturally any attempt at such an endeavor will call for a large amount of labor on the part of many men, and it is not to be supposed that the final solution of the problem will be effected in any short time. The matter of obtaining suitable co-operation with steel makers for the use of their plants so that experiments may be carried out on a scale commensurate with that of practice is one that will have to be taken care of by research men who hope to contribute in large measure to any progress along this line. Steel works laboratories have an opportunity before them if they have not already grasped it—and they apparently have not, if published data can be any criterion. A recent investigation carried out in this country by H. M. Boylston [Carnegie Scholarship Memoirs of the Iron and Steel Inst., Vol. 7, p. 102 (1916)], appears to be the first well-defined attempt in this direction."

Pyrometers.—Before a recent meeting of the Steel Treating Research Club of Detroit, Mich., RICHARD P. BROWN, president of the Brown Instrument Co., of Philadelphia, Pa., presented a paper on "Pyrometers—Past, Present and Future." Mr. Brown gave a history of the development of temperature measuring devices, and pointed out along what lines development in the

future may be looked for. He discussed air, gas, water, optical, radiation, resistance and thermo-electric pyrometers. The thermo-electric method is the one in greatest use and he took up a discussion of the millivoltmeter and potentiometer methods of thermo-electric pyrometry. He said "the advantage of the potentiometer method of measuring temperature, is in its extreme precision, and its independence of resistance changes throughout the thermo-couple circuit. It has the disadvantage as compared with the millivoltmeter method that it is not direct reading, and that some outside source of current, a dry cell, for example, is necessary as a source of current to oppose the thermo-couple, and this cell must be replaced frequently."

In discussing the future for pyrometry, he said "it would seem that the greatest development work in temperature measuring instruments will be done with the perfection of optical pyrometers, resistance thermometers and thermo-electric pyrometers. There is a field for a high grade optical pyrometer which can be used by any number of operators, who will all secure the same results from the instrument. Resistance thermometry will for some time continue to be limited to use at low temperatures unless some suitable metal is found for use in place of nickel to form the bulbs. In thermo-electric pyrometry it is possible to develop better materials than those found to date for base metal thermo-couples. The insulation or protecting tube will be difficult to improve upon. With the direct reading millivoltmeter doubtless the resistance of these instruments will be greatly increased, and I know that we have spent an endless amount of development work the last year or two along this line, and other pyrometer manufacturers are doubtless doing the same thing. The more the internal resistance of the pyrometer can be increased, and at the same time maintain the robustness of the construction, the better the instrument. With the potentiometer method of temperature measurement, doubtless development work can be carried on to advantage in producing an indicating instrument which will be direct reading throughout the scale range, and which will be simplified and less delicate than the types available at the present time. I think, however, the greatest future in pyrometry is along the line of automatic temperature control. I have with me here an instrument which automatically controls the temperature of an electric furnace. By means of solenoid operated switches the circuit is opened and closed through the rheostat, maintaining the temperature constant within 10 deg. Fahr. We have one of these automatic temperature control instruments in use on a japanning oven at the Willys-Overland Co., in Toledo, and nineteen more under manufacture for them. These instruments automatically maintain the temperature constant in an electrically heated oven, and this same type of instrument can just as easily be used on electric heat treating furnaces. We are experimenting with an instrument at present on an American Gas Furnace to operate gas valves, and control the temperature automatically, and while this instrument is in satisfactory operation in our own plant, it is not developed to a point where it is ready for general use. In closing, I wish to also suggest that the various steel manufacturers, and men like yourselves, who are interested in the improvement of heat treating methods, can be of great assistance to pyrometer manufacturers in co-operating with them to test out new devices in an endeavor to improve on present methods. We have made great strides in this country in the past few years in improved methods of heat treatment, and co-operation on the part of all concerned will mean very much greater strides in the next few years."

Recent Metallurgical and Chemical Patents

Sintering

Sintering Fine Ores.—A continuous sintering machine, especially designed for sintering iron oxide ores is patented by HEINRICH BITTMANN, of Frankfort-on-the-Main, Germany. The patent is assigned to the Dwight & Lloyd Sintering Company, of New York City. A longitudinal section of the apparatus is shown in Fig. 1 and a cross-section in Fig. 2. A layer of fuel is fed

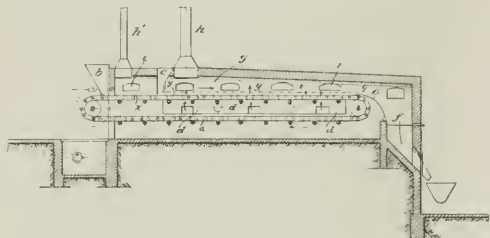


FIG. 1—LONGITUDINAL SECTION OF SINTERING MACHINE

onto the revolving grate *a*, from hopper *b*, and onto the fuel layer is fed a thin layer of ore, or ore mixed with fuel, from hopper *c*. The fuel is brought to ignition between the feed hoppers *b* and *c* by pressure or suction blast. An air box *d* is arranged below the charge support and air is supplied to this box, and passes upward through the grate, fuel and ore. The sintered material is delivered from the grate at the end

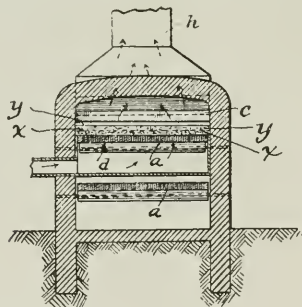


FIG. 2—CROSS-SECTION OF SINTERING MACHINE

e. For conducting away the gases the grate base may be surrounded by a flue space *g*, from which flues *h* and *h'* extend, and the flue may be provided with man-holes *i*. (1,221,962, April 10, 1917.)

Mercury

Roasting Furnace with Fume Condenser.—An ore roasting furnace with condenser which is designed to operate on ores containing volatile metals such as quick-silver and zinc is patented by WILLIAM W. WHITTON, of Oakland, Cal. A cross section of the apparatus is shown in Fig. 3, in which *A* indicates in general a furnace constructed of brick and suitably lined to resist high temperatures; 2 the fire-box and 3 a main heating chamber which is provided with retort tubes generally indicated at *B*. Extending across the main chamber 3 are superposed frames 4, which are provided for the purpose of uniformly distributing the heat from the fire-box about the retort tubes before escaping through the flue indicated at 5, which may be connected with a stack not here shown. Each frame 4 consists of an iron grating, provided with staggered rec-

tangular shaped openings. These openings are provided for the purpose of permitting the insertion of the individual retort tubes and also to permit the same to be readily removed. The furnace gases travel in the direction indicated by the arrows. Extending through each retort tube is a perforated pipe 17. Mounted below the bottom frame 20 is a plate 21 and mounted below said plate is an inclosed tank 22, which is partly filled with water. The lower ends of the individual perforated pipes 17 are connected with the upper end of this tank and the tank is in turn connected through a pipe 23 with a suitable form of condenser 50 and a suction blower 51. Mounted on top of the furnace *A* is an ore-bin 24, the bottom of which is formed by the frame 12 and the open ended retort tubes *B*. The ore delivered to the bin 24 is permitted to fill the individual retort tubes and the ore thus delivered to the individual tubes is prevented from freely discharging through the lower ends by the plate 21. The mercury or other volatile products from the ore are drawn off through

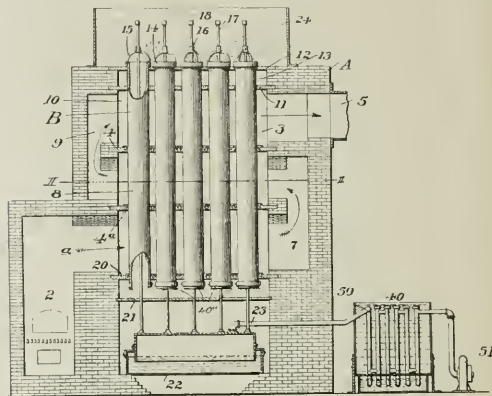


FIG. 3—SECTION OF MERCURY FURNACE

pipe 17 by suction from the condenser and blower. The liberated volatile products are thus drawn directly into the tank 22, where they strike the surface of the water contained therein. A comparatively large proportion of the products are here condensed and permitted to settle in the form of a pure metal while the remaining products are drawn through the pipe 23 where they are finally precipitated in the condenser. With a furnace constructed as described, the products of combustion are not brought into direct contact with the ore nor is the ore raised to a temperature which will liberate the injurious corrosive gases such as sulfurous or sulfuric acid. (1,222,251, April 10, 1917.)

Calcium Carbide

Calcium Carbide and By-product Recovery Furnace.—An electric furnace, adapted to produce calcium carbide and coal tar products is patented by J. H. REID of Newark, N. J., and assigned to the Patents Process Company, a Maine corporation. A cross-section of the furnace and condenser is shown in Fig. 4. The furnace proper is simple in construction. From the cover, extends the outlet 18 provided with the fluid seal 19 and the revolving damper 20. The upper section or cover 9 is also provided with a sealed feed inlet 21 the seal of which may be removed and replaced while supplying ingredients to the apparatus during the performance of the process and closed during the condensing operation. The outlet 18 with its fluid seal 19 communicates with a removable conduit 25 operating

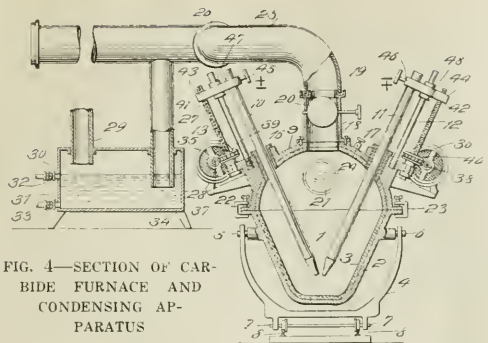


FIG. 4—SECTION OF CARBIDE FURNACE AND CONDENSING APPARATUS

through the swinging joint 26. This conduit communicates with an outlet 27 leading to the reservoir 28 and through which the condensed volatile products pass to the same, the reservoir 28 being provided with an outlet 29 for the permanent gases and whereby the said gases are conveyed to a reservoir (not shown). The apparatus is stated to be applicable to the production of calcium carbide from bituminous shale and lime, with the recovery of tar or volatile products such as benzol, toluol, etc., evolved during the action of the electricity on the charge. (1,224,788, May 1, 1917.)

Welding

Welding Compound for Nickel and Nickel Alloys.—

A flux for use in the autogenous welding of nickel and nickel alloys is patented by RICHARD SAMSEREUTHER, of Dusseldorf, Germany. The object of using the flux is to overcome the absorption of oxygen and other gases and embrittlement of the welded piece on cooling. Porosity is also claimed to be overcome. The essence of the invention is that in order to effect a proper welding of nickel or nickel alloys, there must be present (in addition to metal of the same character as the one to be welded) three substances or ingredients, viz. first, alkali, second metal chloride, and third, chromium. The purpose of the alkali is, stated above, to form a fireproof film during welding. This film, however, would prevent the parts to be welded from fusing together, and to avoid this detrimental action, metal chlorid and chromium are used during the welding process. Waterglass may be used as the alkali and chlorides of magnesium or molybdenum as the metal chlorides. Chloride of calcium may also be added to dissolve any possible slags. (1,224,418, May 1, 1917.)

Light Alloys

Aluminium-Calcium Alloys.—Aluminium-calcium alloys and the process of manufacture are patented by HUGH S. COOPER, of Cleveland, Ohio, (assigned to the Cooper Company, of Cleveland, Ohio). An alloy of 8 to 10 per cent calcium and the balance aluminium which is the favored composition is much lighter than aluminium alone, is stated to be much harder, more resistant to corrosion and to machine easily. The calcium also acts as a deoxidizer. The process of manufacture is described in the specification as follows:

In view of the fact that calcium burns, even when heated to a low temperature, the alloy cannot be made by simple fusion of the mixed metals. Consequently, the steps practiced by me in making these alloys is to melt the aluminium first and heat to about 800 C. The melted product is then removed from the fire and calcium in the form of small pieces pushed under the surface of the melted aluminium and held there until melted. Upon the introduction of each piece of calcium a slight reaction takes place with a rise in

temperature of the melt, and when the proper amount has been added the alloy is stirred rapidly and immediately poured into molds. Care must be taken that the calcium does not float on the surface of the aluminum, as in this case it would rapidly burn to the oxid without formation of alloys. After the melted aluminum has been removed from the fire, the introduction of each calcium piece produces a reaction which generates sufficient heat to keep the alloy in a melted condition until all the needed calcium has been added.

The alloys are especially useful for the manufacture of light castings for automobiles, aeroplanes, etc. (1,224,362, May 1, 1917.)

Iron and Steel

Ferro-alloys and High Speed Steel.—Two patents of ISADOR LADOFF, of Wilksburg, Pa., deal with the production of ferroalloys and high speed steel. The first (No. 1,221,873, April 10, 1917), describes a method of making ferroalloys by heating a mixture of the oxides of the metals in proportions calculated to insure the desired percentage of the metals in the alloy. Thus, for instance, uranium, chromium, vanadium, and iron oxide, may be used. To this mixture is added an auxiliary oxide such as arsenic, antimony, nickel, or cobalt. The charge is then heated below the melting points of the metals in the presence of a reducing agent until the desired alloy has been produced. The auxiliary oxide mentioned above is claimed to render the alloying metals more miscible and therefore more readily alloyable. The second patent (No. 1,221,874, April 10, 1917) describes the production of high speed steel by producing in one heat a preliminary quaternary alloy of ferro-metal with tungsten, chromium and vanadium in the proper proportions and then melting the alloy in a bath of ferro metal not comprised in the alloy. The tungsten-chromium and vanadium constitute not less than 50 per cent of the preliminary alloy, which is produced by reducing the oxides of the constituent metals at temperatures below their melting points.

Youngstown Chemists' Club.—The Youngstown Chemists' Club closed a very successful season with a dinner Wednesday evening, May 16, followed by an excellent program. Mr. F. E. Dodge, chief chemist of the Barrett Co. gave a most interesting impromptu talk on "The Benzol Situation," Prof. H. E. Whitfield of the University of Western Australia and British Inspector of Materials at Pittsburgh, explained some of the British methods of testing the materials for shells and other munitions. Mr. W. C. Anderson, chief chemist of the American High Explosive Co. of New Castle, Pa., spoke on "The Chemistry of High Explosives and Permissibles," exhibiting some very interesting samples.

Illinois Mining Engineers' Meeting.—The Illinois Mining Institute and Chicago Section of the American Institute of Mining Engineers held a joint meeting and field trip May 17, 18 and 19, with headquarters at La Salle, Ill., at the Hotel Kaskaskia. A meeting was held on Thursday afternoon, May 17, and a reception Thursday evening. Meetings were also held on Friday morning and evening, and a joint dinner Friday evening. On Friday afternoon and all day Saturday inspection trips were made to various plants and points of interest. The excursions included the works of the Marquette, Lehigh and German-American cement companies, the mines of the Illinois Zinc Co. and the La Salle County Carbon Coal Co., and the zinc smelting works of the Matthiessen & Hegeler Zinc Co., the Illinois Zinc Co. and the Mineral Point Zinc Co. These works produce spelter, sheet zinc, sulphuric acid, zinc oxide and acid phosphate.

The Supply of Platinum

The known supply of metals of the platinum group in the world is possibly 5,000,000 ounces. Estimates based on the official figures of production from Russia since 1843, which are taken as 25 per cent too low, and on the assumption that Russia has supplied 95 per cent of the world's output, indicate that the total quantity of crude placer platinum produced in the world since 1843 has been less than 4,632,000 troy ounces, or about 159 short tons.

Crude platinum is not pure, as it contains, besides iron, small amounts of one or all of the metals iridium, palladium, osmium, rhodium, and ruthenium. It is difficult to estimate the quantity of platinum in the world, but it is perhaps within reason to say that the platinum in the world's stock of metals of the platinum group amounts to 4,000,000 ounces.

From the most reliable information in the hands of the United States Geological Survey, it is estimated that the total quantity of platinum in the United States is about 1,000,000 ounces, besides which there is over 400,000 ounces of other metals of the platinum group, principally palladium, iridium, and rhodium.

In 1916 the crude platinum mined in Colombia, estimated at 25,000 ounces, was refined in the United States, and reports received from domestic refiners show that 28,088 ounces of metals of the platinum group was recovered by them from all sources, foreign and domestic, of which 24,518 ounces was platinum.

ESTIMATED WORLD'S PRODUCTION OF CRUDE PLATINUM, 1909-1916, IN TROY OUNCES

Country	1909	1910	1911	1912
Borneo and Sumatra	500	200	.....	.....
Canada	30	30	30	30
Colombia	6,000	10,000	12,000	12,000
New South Wales and Tasmania	440	332	470	778
Russia	264,000	275,000	300,000	300,000
United States	672	390	628	721
	271,642	285,952	313,128	313,529

Country	1913	1914	1915	1916
Borneo and Sumatra	200	.....	.....	.....
Canada	50	30	100	.....
Colombia	15,000	17,500	18,000	25,000
New South Wales and Tasmania	1,500	1,248	302	222
Russia	250,000	241,200	124,000	63,900
United States	483	570	742	750
	267,233	260,548	143,145	89,932

*No basis for estimate.

It is known that the Colombian deposits will be more extensively developed during 1917 than ever before, and it is estimated that at least 30,000 ounces of crude platinum, containing 85 per cent metal, will be derived from that source. It is hoped that in 1917 deposits in the United States will yield more platinum than heretofore, that platinum derived from all sources other than foreign crude may exceed 7000 ounces, and that the production of crude platinum will be at least 10 per cent greater than in 1916.

The Russian situation is very difficult, but it is known that there are considerable stocks of crude platinum held in Russia which are available to the allied governments. It is believed that the production from Russia in 1917 will be considerably increased, perhaps equaling the 1915 output.

Apparently the normal requirements of platinum in the United States call for 165,000 ounces a year, part of which is supplied by refining scrap and sweeps from the various industries using platinum. It is estimated that the dental industry formerly used between 25 and 30 per cent of the supply, part of which cannot be considered as recoverable. However, dental manufacturers are now using a number of alloys in place of platinum. It is estimated that the jewelry industry uses between 40 and 50 per cent of the supply, practically all of which would be recoverable if necessity arose.

There is no available information concerning the quantity of platinum in chemical utensils in the many hundred laboratories throughout the United States, but it is probably not much over 10 or 15 per cent of the supply and is all recoverable.

In 1915 about 44,000 ounces, or 4 per cent of the apparent United States stock of platinum, was used in contact-process sulphuric acid works. The acid made in these plants is very strong, and its use at this time is limited practically to munition makers. The production of sulphuric acid of grades in use in ordinary chemical industry does not depend on catalytic platinum, as such acid is made in lead chambers. The output of contact-process plants has increased nearly 200 per cent since 1915, and it is understood that plants using this process are not yet operated to their full capacity. It therefore would not appear that there is any pressing need for a large supply of platinum by the sulphuric-acid industry.

The Government laboratories are apparently well supplied with platinum utensils, and are not in the market for platinum at present, except as investigations on a larger scale may require new equipment. The United States mints are known to refine platinum and doubtless have stocks sufficient to meet any immediate governmental requirements.

A census of stocks of unmanufactured platinum in the United States that can be considered as immediately available is now being taken by the United States Geological Survey. From the information already available it would appear that there are supplies of platinum sufficient to meet such extensions of contact-process plants as may be required immediately.

From the foregoing statements the available supply of platinum in the United States appears to be adequate to meet immediate needs, but it should be emphasized that new demands may arise at any time which the present stocks of platinum in this country could not meet.

The jewelry industry has voluntarily agreed to limit the use of platinum in jewelry during the war.

It may be advisable to state that industrial expansion in the future may make necessary the further curtailment of platinum in the manufacture of jewelry in order that an adequate supply of this metal, which is essential in many chemical industries, may be assured.

Metallurgical Fellowships.—Dean Milnor Roberts of the College of Mines, University of Washington, announces that twenty applications for the mining and metallurgical research fellowships offered by the U. S. Bureau of Mines in connection with the University College of Mines, have been received. Winners of the scholarships will receive \$720, and will conduct extended research study along lines of mining and metallurgical work that will be of special importance to the Pacific Northwest and Alaska.

Wood Oils.—The Forest Products Laboratory, Madison, Wis., has recently conducted considerable experimental work on wood oils. In the refining of crude hardwood distillates, the tar is distilled with steam to recover the acetic acid and alcohol, and during the distillation some light-gravity, low-boiling oils are also distilled over. These are commonly called "wood oils." It has been known for some time that these oils possessed very valuable solvent properties, but the very disagreeable odor and the permanent yellow color were very disadvantageous. It has been found by the Forest Products Laboratory that, by hydrogenation, the color can be very much improved and the odor changed to a distinctly agreeable ketone odor, and that this can be done without any marked change in the other physical or chemical properties.

A New Dry Concentrator

A new type of dry concentrator known as the Elsol concentrator has been designed and placed on the market by Young & Tyler of Los Angeles, Cal. It is stated that successful results have been obtained on gold, silver, lead, zinc, copper and antimony ores with this machine. A diagram is given in Fig. 1.

Ore from the hopper *C* is fed onto a specially constructed metal surface *F*, over which is a cover with pipe *K* attached, connected to settling cone *B*.

The bottom side of all riffles are perforated with a nozzle-like perforation placed at such angle as to not only give the lifting effect on the material (thus allowing the values having the higher specific gravity to settle to the bottom), but also to aid in a more rapid advance of the material along the riffles.

The exhaust, which draws fine dust up through pipe *K*, is furnished by connecting the return air pipe *E* to the tank *B*. The fine dust is discharged at *H*.

The riffles of the concentrator are of an obtuse angled V-shape with one side—the front or bottom side—longer than the other, and when in its working position a cross-section presents an appearance similar to that of the lip of an ordinary gold pan when being used by an expert panner.

At the upper or feed end of the table these riffles are of comparatively large cross-section and gradually taper down to a small cross-section at the concentrate-discharge end *G*. The object of this is twofold: It gives a greater longitudinal angle to the upper riffles, besides reducing the capacity per unit length of riffle as the discharge end is approached.

The greater longitudinal angle has the effect of holding the values more securely once they have been caught, since the riffle cuts more sharply across the line of travel of the table movement. The reduction of cross-section has the positive effect of eliminating the gangue matter which may be riding near the top of the riffle.

The table movement is accomplished by a set of eccentrics which together with a relatively high rotation give the rapid progressive movement of the material.

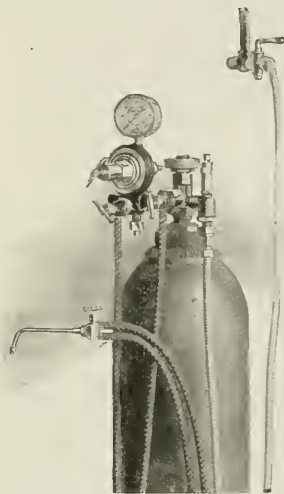
The concentrator is built in capacities ranging from 1 to 12 tons per hour on coarse crushed quartz ores, and from 2 to 40 tons per hour on ordinary gold placer. The

capacity depends largely on the quality of the ore and upon the percentages of values carried, the lower the percentage of values the higher the capacity.

It is claimed that the horsepower required varies from less than 1 on the small size to $2\frac{1}{2}$ to 3 on the larger sizes.

Oxy-Illuminating Gas Lead Burning Apparatus

Apparatus for lead-burning with oxygen and natural or artificial illuminating gas, known as "Astra" apparatus, has been developed by Ashton, Laird & Company of New York, and is being placed on the market through



PORTABLE WELDING APPARATUS

its agents, the Bradford-Ackermann Corporation, Forty-second Street Building, New York.

Two standard models are made, a stationary and a portable type. The portable type is shown in Fig. 1. It includes a flexible metallic gas hose connected to the gas main and oxygen tank and to the regulator and torch, as shown. A working range of 18 ft. is provided by the hose, which can be increased by means of additional hose.

A specially designed pressure-reducing valve, with safety attachment, serves as the oxygen regulator. This is supplied with a gage to indicate the working pressure at the burning nozzle. A high-pressure gage, furnished separately, can be attached to determine the initial contents of the oxygen tank when received, or when it is nearly exhausted, or the quantity of gas used in each operation. The apparatus also includes an oxygen back-pressure release valve for the illuminating-gas line. This device, and the safety device on the oxygen regulator, operate automatically, and are provided with alarm whistles to attract attention.

The two-hose torch is provided with a valve, as shown, which can be used to shut off the oxygen supply between operations, leaving only the illuminating gas as a pilot light.

The apparatus is so assembled that its different component parts may be added to existing welding, or decarbonizing apparatus to provide lead burning facilities. Other Astra appliances may be added in order to include hard soldering, brazing, tempering, etc.

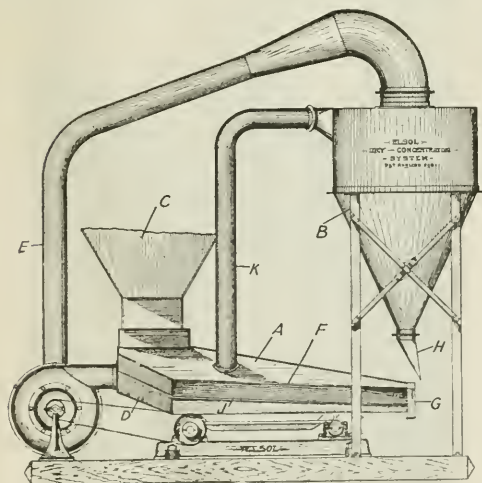


FIG. 1—DIAGRAM OF DRY CONCENTRATING SYSTEM

A New Hardness Tester

An instrument designed by Dr. Leonard Waldo for determining the hardness of metals under service conditions is shown in the illustration Fig. 1. The requirements of such an instrument are that it should be easily portable and that its indications should be uniform over indefinite periods of time, and subject to easy calibration.

The instrument consists of a plummet weighing 1 10 lb. and falling 1 ft. to the surface of the material whose hardness is to be measured. This plummet *P* shown in the illustration has a conical, replaceable, chill-tempered, 60 deg., steel point *G*. This plummet has tied to its upper extremity a very thin silk thread which bends over a funnel-shaped end piece *ABC*, into which, at *A* and *B*, slotted holes are cut with burnished edges such that the silk thread passes through them with practically no friction loss. The funnel *ABC* turns with a slight friction in the end of the jointed supporting brass tube *IC*. The silk thread is attached to a small burnished ring at its lower end, which ring in turn is caught in a little trigger at *H*, which can be released by the thumb screw *I* without jarring the instrument. The silk thread then passes from the release catch *K* through the hole *A*, through *B*, through an adjustable third hole at *E*, which is clamped in place by the thumb screw *D* so that the plummet point *G* is exactly over the aperture *O* in the base of the instrument.

The base of the instrument is supported on three points, two of which are controlled by leveling screws *J*. Small cross levels indicate the verticality of the supporting rod *IC*.

In use, the instrument is set on the surface of the material whose hardness is to be tested, so that the aperture in its base *O* is concentric with the exact spot to be tested. The plummet is then hung as shown, and lowered by holding the

silk thread by its ring between the fingers so that the exact position of the clamp *DE* may be found for insuring the vertical fall of the plummet. This being determined, with the instrument leveled, the thread ring is placed in its releasing trigger *H*, and with the plummet in its position *FG*, the funnel support *AB* is gently turned until the distance from the conical point *G* to the surface of the material to be tested *O* is exactly 1 ft.

When the plummet is still the trigger is released by the thumbscrew *H*, and the plummet falls, making a uniform circular indentation in the material tested. The object in releasing the plummet from the bottom of the apparatus is to avoid disturbance in its upper support. A small portable microscope (Fig. 2) is then used. It is designed so that it has sufficient illumination and magnifying power to measure easily with an eyepiece micrometer the diameter of the impression made by the falling plummet point. A scale for measuring indentations is embodied in the microscope.

The apparatus is being placed on the market by the Palo Company, 90-94 Maiden Lane, New York City.

Cooling Condensing Water in a Dyestuff Plant

The desire for quick and rapid production of new dyestuffs and other chemical products in order to take advantage of the markets has made it necessary for a great many plants to adopt makeshifts for certain of their operations, which while giving the desired result would probably not be considered if the element of time did not enter so strongly into the work. The illustration, Fig. 1, shows a method adopted by one of the large vegetable dye concerns to cool the water used to condense vapors arising from the various processes. The method has been in successful operation since last October, cooling 200 gal. of water per minute from a boiling temperature to 70 to 90 deg. Fahr. The trough on the tank is 22 in. wide and its lip is 15 ft. from the reinforced concrete tank. The tank itself is about 20 ft. x 30 ft., and is 13 ft. deep.

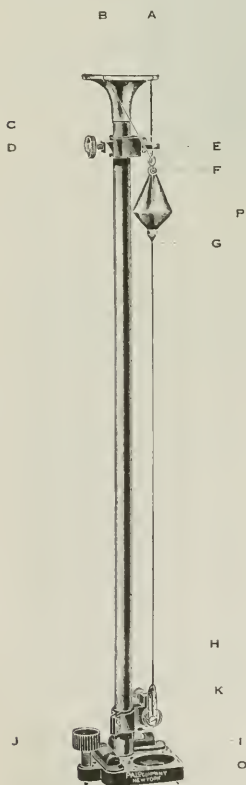


FIG. 1—WALDO HARDNESS TESTER

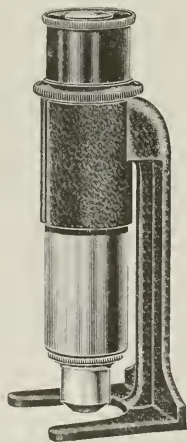


FIG. 2—SMALL PORTABLE MICROSCOPE



FIG. 1—HOT WATER TANK AND COOLING POND

Personal

Dr. Marston T. Bogert has been granted leave of absence from Columbia University and is devoting all his time to the work of the National Research Council, of which he is chairman of the Chemistry Committee. His headquarters are in the Munsey Building, Washington, D. C.

Dr. Allerton S. Cushman, president of the Institute of Industrial Research, Washington, D. C., has been commissioned a major in the Officers' Reserve Corps, and will do special research work under the ordnance section on the chemistry of high explosives.

Mr. B. A. Foley has terminated his connections as assistant manager with the Palo Company, and is now associated with the Lenz Apparatus Company, Inc., 9-11 East 16th Street, New York.

Mr. H. A. Ford has resigned his position as steam engineer with the Bethlehem Steel Co., South Bethlehem, Pa., to become assistant superintendent of the Union Carbide Co.'s plant at Sault St. Marie, Mich.

Mr. J. H. Herron has been elected president of the Cleveland Engineering Society. Messrs. S. T. Wellman and Ambrose Swasey, both past presidents, have been made honorary members of the society.

Mr. Bernard MacDonald has accepted an engagement which will occupy his time indefinitely as consulting engineer with headquarters at Antofagasta, Chile.

Mr. Edwin S. Pettis of the Oliver Continuous Filter Company, San Francisco, Cal., was recently in New York on business for his company. He reports great activity in the chemical field.

Mr. E. Gybon Spilsbury sailed on June 5 for Central America and expects to be absent until the middle of July.

Mr. V. C. Suckow, chief inspecting engineer with Falkenburg & Laucks, Seattle, Wash., has received a captain's commission in the Engineers' Corps and has reported for duty at the Presidio at San Francisco.

Mr. F. H. Tackaberry has been appointed traveling representative of the American Steel Export Co. of New York. He has recently been associated with the Ordnance Engineering Corporation of New York and has occupied important executive positions in such organizations as the Industrial Underwriters, Inc., the Locke Steel Belt Co., etc.

Book Review

Standard Methods of Chemical Analysis. Edited by Wilfred W. Scott. Octavo (15 x 23 cm.), 864 pages. 145 illustrations. Price, \$6.00 net. New York: D. Van Nostrand Company.

This dignified volume is intended for general reference for analytical chemists and advanced students. The editor is research chemist for the General Chemical Company, and has associated with himself seventeen competent specialists.

Part I takes up alphabetically the determination of the elements, all sections being written by Mr. Scott except "Cerium and Other Rare Earths," "Zirconium" and "Thorium," by R. Stuart Owens, "Chlorine" with the assistance of W. F. Doerflinger, "Copper" with the assistance of W. G. Derby of the Nichols Copper Company, "Gold" and "Silver" by W. G. Derby, "Nickel" by W. L. Savell, "Platinum and Allied Rare Metals" by R. E. Hickman of Bishop & Company, "Potassium and Sodium" by W. B. Hicks of the U. S. Geological Survey, "Tin" by H. A. Baker and E. S. Clark of the American Can Company, "Titanium" with the assistance of L. E. Barton of the Titanium Alloy Manufac-

turing Company, and "Zinc" by F. G. Breyer of the New Jersey Zinc Company.

Part II deals with special subjects, in which Mr. Scott himself writes on "Acids," D. K. French on "Water Analysis," A. H. Gill on "Fixed Oils, Fats and Waxes" and on "Gas Analysis," H. A. Gardner and J. A. Schaeffer on "Paints," R. K. Meade on "Cements," J. C. Olsen on "Alloys," F. E. Hale on "Coal" and W. G. Derby on "Assaying."

We find Part I more satisfactorily written than Part II. Under each element the treatment is broad and comprehensive, giving the general bases for determination of the element under varying conditions and in different combinations. The book would have been highly satisfactory if it had ended with Part I. The second part is sketchy and less satisfactory. Many special problems, such as the analysis of foods, asphalts, alloy steels, ferro-alloys, etc., which really require special treatment, are not touched, while those subjects which are treated are not always handled satisfactorily, e.g. alloys and assaying.

The book, as a whole, deserves a place in every chemical laboratory.

CURRENT MARKET REPORTS

The Iron and Steel Market

The lapse of a fortnight has furnished additional basis for the view expressed in last report that the steel market had gotten onto a new tack, with less disposition on the part of buyers to contract for late deliveries and less tendency for prices to advance.

The steel market, however, has always displayed an ability to cover up its tracks at a juncture like this, and the present is no exception. There develops, let us say, an indisposition on the part of buyers to contract for deliveries as far ahead as formerly, whereupon the sellers accept the situation and make not the slightest effort to encourage buyers by making price concessions, as they know perfectly well that such action would have the opposite effect. Meanwhile the demand for early deliveries continues on the part of those not fully covered, and as the early deliveries usually command premiums, the average price at which business is done tends to advance at a time when buyers are really displaying less confidence in the future. This is approximately the situation to-day. Some steel products are bringing higher prices than recently, for early deliveries, while ordinary forward buying is light.

The Steel Corporation's unfilled tonnage statement indicates that the volume of obligations on books is equal, in tonnage, to its production for nine months. The larger independents are in somewhat the same position. Some departments are sold much farther ahead, some not as far ahead. Obviously the buyer is taking a long chance in placing a contract for delivery after the present business is filled. The country may then be at peace or it may be facing the prospect of one or two years more of war. A period of market quietness is to be expected, even though consumption may be likely to continue at its present rate. Of this, however, there certainly must be considerable doubt.

The condition as to steel market prospects beyond the next few months is certainly a complicated and confusing one, and not the less so by the ready adoption in some quarters of various fallacies. On the one hand the urgent need for ships is taken as indicating heavy demand for steel for shipbuilding, while the corollary, that if ships are very scarce it will be difficult to export steel, is not considered. Again, the demand for steel for government account, building ships, making tent stoves, camp ranges, helmets, a thousand and one things,

is taken as adding so much to the total demand for steel, without allowance being made for the fact that all the steel must be fabricated or worked up in one way or another, largely with existing facilities, which to that extent can no longer be employed in fabricating the steel they have lately been taking. A factory working up steel may have its tonnage consumption reduced by its being turned onto Government work. The business is not necessarily so much addition. Another fallacy is that each ton the Government takes will correspondingly decrease the total supply of steel. As the industry is highly specialized, only so much steel can be put into sheets, so much into plates, into wire, and so on. Assume a manufacturer who makes a ware from sheets and bars in equal tonnages. Let the Government take sheets and not bars. For every ton of steel, in the sheet form, the Government takes, the factory consumes two tons less steel, because it cannot get the ton of sheets and therefore does not want the ton of bars either.

STEEL FOR GOVERNMENT

The Government requirements in steel are not being formulated rapidly. Some opinions must be altered. It has been found undesirable for the Government to buy steel and farm it out to factories and shops for conversion into the useful product. The purchases are to be made of the finished products, and it takes time to make them, so that the steel orders are percolating through to the steel mills rather slowly, in point of tonnage. When it is considered, however, that with a long war the business represents in each case not so much a specific tonnage as a rate per month, to be continued indefinitely, the proportion of the country's steel output that eventually will be passing to Government account seems likely to be larger than was at first estimated. Two months ago an altogether outside estimate was 20 per cent of the total output. If export shipments can be made freely to our Allies and things work well in the matter of finding fabricating capacity to turn rolled steel into useful forms the proportion may in time exceed 20 per cent and may conceivably reach 30 or 40 per cent.

STEEL PRICES

There is no longer any well-defined steel market. Formerly there were well-recognized prices for finished steel products for forward delivery, this developing practically into "delivery at mill convenience," but these prices first became nominal and then disappeared altogether. It is a question of tonnage, delivery and specification, every order with a price of its own. Roughly speaking, for delivery from three to six months hence tank plate is 7c. to 8c., with ship plates, Lloyd's specifications, in the neighborhood of 10c.; bars, 4c. to 4.25c.; structural shapes, 4c. to 4.50c.; blue annealed and black sheets, 7c. to 8c., galvanized sheets about 10c.; wire nails, \$3.50 to \$3.75. There is no tin plate market. The respectable mills, practically all, are devoting their output to taking care of the perishable food crops and have nothing to offer.

PIG IRON'S INNING

What was suggested a fortnight ago as possible, seems to be coming rapidly to pass. It is pig iron's inning. Throughout this movement, until very lately, the thin neck of the bottle was the steel making capacity. There was plenty of pig iron for the steel-making departments and plenty of rolling capacity—except in plates—for the ingots. Lately, conditions have been changing. Steel-making capacity has increased much more than blast-furnace capacity, and it is impossible for all the furnaces in blast to maintain full output continuously on account of shortage of coke, through car shortage

in the Connellsville region and at coal mines supplying by-product ovens. This is the trade's interpretation of the sharp advances in pig iron. In the past fortnight the following advances have occurred: At valley furnaces, Bessemer, \$5; basic, \$3; foundry, \$2; foundry at Birmingham, \$2; at Philadelphia, \$1; at Chicago, \$3. Last sales of Bessemer were at \$50, valley, 35,000 tons altogether, while last sales of basic were at \$45, but at this writing there does not appear to be any more available and by June 15th the market may be established by sales at more than \$50 for each grade. It may be remarked that while higher than present prices for pig iron ruled late in the Civil War and for two or three years thereafter, \$50 Bessemer iron is the highest in recorded history, as there was no Bessemer iron at that time, as the market commodity, the first reported production of Bessemer steel having been in 1867, a couple thousand tons.

Non-Ferrous Metal Market

Friday, June 8.—Copper remains virtually unchanged. Tin has declined following a decline in London. Lead has been advanced \$10 per ton by the Trust. Spelter is unchanged. Antimony has declined further on freer offerings. Silver has advanced slightly.

Copper.—Prices for prompt and June copper remain practically unchanged with Electrolytic averaging 31.50 cents and Lake 32.50 cents. The strike at Jerome, Arizona was settled June 4, and 1500 men returned to work. At the time of writing no announcement has come of the prices to be paid for copper purchased by the Government. A census is undoubtedly being taken of the possible production during the year and of consumers' requirements. July electrolytic is offered at 31.50 to 32.00 cents, third quarter at 30.00 cents and fourth quarter at 29.00 cents.

Tin.—The market in London declined considerably the first week in June, but on June 7 began to recover. Our prices followed those abroad and spot Straits dropped from 65.00 cents on May 23 to 60.50 cents on June 6, but recovered to 61.00 cents on June 7. The market has been quiet and futures have been very dull. The uncertainty as to the tax and the British regulations have had a dampening effect, but it is hoped that the Tin Committee, appointed as a sub-committee of the Council of National Defense will straighten out the tin situation. At present the committee is obtaining data on stocks and requirements of consumers. Arrivals for May were good, totalling 5895 tons. Deliveries at Atlantic and Pacific ports were 4200 tons.

Lead.—The trust price of lead was advanced to 10.50 cents New York on June 7. The advance was expected and follows a long period of scarcity of supplies. It is reported that increased production in this country and in Mexico should have its effect before long in the lead market, although there are no signs yet of any let up in demand.

Spelter.—Buying continues very dull with spot spelter unchanged at 9½ cents New York basis. It is understood that production is on a smaller scale. Futures up to fourth quarter are quoted at the same figure as prompt shipment.

Other Metals.—Antimony has declined from 23.25 on May 23 to 20.75 on June 7. There has not been much demand for prompt, but futures are in good demand. For July shipment 19.00 cents is asked and 18.00 cents for August. Aluminium is unchanged at 60.00 cents for No. 1 Virgin. Magnesium can be had at \$2.25 to \$2.50 for prompt shipment, and for less on contract. Quicksilver is \$90.00 per flask. Pure platinum is \$105 per ounce. Silver is 75⅜ cents per ounce. Tungsten concentrates are \$17.00 per unit for wolframite and \$17.50 for scheelite.

Chemical Market

Coal-Tar Products.—Business in practically all items under this classification has been much restricted during the past two weeks, due to the general unsettled conditions prevailing. The possibility of a 10 per cent duty on free and dutiable goods tends to hold up transactions on English products, and the uncertainties governing war purchases on the other hand tend to restrict offers of domestic materials entering into the manufacture of munitions.

Benzol.—In contrast to the situation that prevailed only a short time ago, supplies of benzol have been quite abundant during the interval, and even the large producers have found difficulty in disposing of their holdings. Consequently, there has been but little activity noted, and the market has exhibited a rather weak tone, with some tendency to firmness at the moment of writing.

Aniline Oil.—The situation has been rather peculiar. After a period of extreme firmness for more than a month the demand experienced a lull, and a holder of one car possessed the product for more than a week without selling it. As soon as this material was cleared from the market, however, a feeling of firmness ruled, and the market advanced somewhat. Generally speaking, the outlook for aniline oil is bright, and there is a probability that higher prices are to prevail. Some producers who dropped out when low prices ruled have come back, and are now offering in a moderate way.

Monochlorobenzol.—There has been nothing of special note to report regarding this product. Supplies have increased and offerings have in some instances been made on a much lower level than any heretofore prevailing. Production now is quite important, and will probably increase.

Toluol.—In contrast to benzol, the toluol market is quite stiff, and prices have ruled on a higher level. In anticipation of important government business, holders are not inclined to dispose of their holdings, and have, turned down big business. Prices have been stiff.

Toluidines.—There has been no important change to record with important sales noted of *para*, with *ortho* somewhat restricted in demand. Mixed *toluidine* has practically disappeared from the market, although some inquiry is still noted.

Phenol.—The production continues to increase and in excess of the demand. Middle Western producers have been offering at prices somewhat below those prevailing in the East, and producers generally do not appear to be very well pleased with the situation, which has shown practically no important movement for months past.

Dinitrophenol.—Offerings of this product have been restricted. Values have remained moderately firm, but nothing of special importance has transpired.

Naphthalene.—English flakes are still offered at low prices in bond, but do not appear to attract much consuming inquiry. Prime domestic flakes are rather firm, but are not changed materially since our last report.

Paradichlorobenzol.—To use a pun, this product is a drug on the market. As a by-product, supplies are accumulating rapidly, and some holders have expressed a willingness to dispose of holdings at any reasonable price a buyer will set.

Paranitrophenol.—The manufacture of this product appears to be confined to one source, and there is good demand reported at favorable prices. *Ortho*, on the other hand, drags, and sales are difficult.

Heavy Chemicals.—Business has been small and unimportant during the intervals, with prices generally higher, but in some instances notably lower.

Bleaching Powder.—An extremely weak condition prevails, due it is stated to an important production by consumers from their own cells. There has been little export business, and the paper mills have been reselling contracts.

Caustic Soda.—In contrast, the market for caustic rules high, but the speculative interest is still pronounced, and it is predicted that when this element is eliminated a break will occur.

Soda Ash.—The market has not been particularly strong. A fair demand has prevailed, but prices remain about stationary. Some inquiry for 1918 has prevailed. Dense ash is in urgent demand, and high.

Formaldehyde.—The market has probably reached its highest point. It continues strong, however, but there seems to be little likelihood of any consumer paying more than present record prices.

Zinc Oxide.—A sharp advance has occurred, and supplies continue very scarce, with many important inquiries still unfilled.

Cyanides.—With the exception of potassium, all grades have ruled weaker in face of important Japanese competition.

Copper Sulphate.—While business has not reached important proportions, prices rule steady, and producers are quite firm in their views.

Barium Compounds.—There has been a rather brisk inquiry for these products, particularly the carbonate.

Carbonate of Potash.—Short interests find difficulty in covering. Their supplies are very light and prices high.

Acetate of Soda.—The demand has improved materially, and more money has been secured.

Phosphate of Soda.—Offerings have not been as free as heretofore and the commercial variety shows an advance in price.

Acids.—All grades of *acetic* are higher, with supplies scarce. There has been more activity noted in *muratic*, and prices are higher in some directions. *Nitric* has been higher, due to the increased cost of raw materials rather than to any increased activity. *Sulphuric*, both pyrites and brimstone, has been firm and fairly active. *Oleum*, however, is somewhat off, owing to an increased output.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET JUNE 7, 1917

Acetic anhydride	lb.	1.70	—	1.80
Acetic, drums	lb.	.27	—	.27 1/2
Acid, acetic, 25 per cent.	lb.	.05	—	.05 1/2
Acetic, 56 per cent.	lb.	.09 1/2	—	.10
Acetic, glacial, 99 1/2 per cent, carboys.	lb.	.31	—	.32
Boric, crystals	lb.	.11	—	.11 1/2
Citric, crystals	lb.	.73 1/2	—	.75
Hydrochloric, commercial, 18 deg.	lb.	.01 1/2	—	.01 1/2
Hydrochloric, 20 deg.	lb.	.01 1/2	—	.01 1/2
Hydrochloric, C. P., cone, 22 deg.	lb.	.01 1/2	—	.01 1/2
Hydrofluoric, 30 per cent, in barrels	lb.	.04 1/2	—	.05
Lactic, 44 per cent.	lb.	.11	—	.12
Lactic, 22 per cent.	lb.	.04 1/2	—	.05
Nitric, 36 deg.	lb.	.06 1/2	—	.07
Nitric, 42 deg.	lb.	.07 1/2	—	.08
Oxalic, crystals	lb.	.16	—	.17
Phosphoric, 85 per cent	lb.	.35	—	.37
Picric	lb.	.70	—	.75
Pyrogallol, resublimed	lb.	3.50	—	4.00
Sulphuric, 60 deg.	ton	27.00	—	28.00
Sulphuric, 66 deg.	ton	30.00	—	35.00
Sulphuric, oleum (Fuming), tank cars	ton	35.00	—	40.00
Tannic, U. S. P., bulk	lb.	.45	—	.50
Tartaric, crystals	lb.	.70	—	.82
Alcohol, grain, 18 proof	gal.	3.06	—	3.08
Alcohol, wood, 95 per cent	gal.	1.00	—	1.02
Alcohol, denatured, 180 proof	gal.	.72	—	.73
Alum, ammonia lump	lb.	.01	—	.01 1/2
Alum, chrome ammonium	lb.	.18	—	.19
Alum, chrome potassium	lb.	.50	—	.32
Alum, chrome sodium	lb.	.12	—	.12 1/2
Alum, potash lump	lb.	.06 1/2	—	.07
Aluminum sulphate, technical	lb.	.02	—	.02 1/2
Aluminum sulphate, iron free	lb.	.03	—	.03 1/2
Ammonia aqua, 26 deg. carboys	lb.	.06 1/2	—	.07
Ammonium carbonate	lb.	.13	—	.14
Ammonium nitrate	lb.	.16	—	.17
Ammonium, sulphate domestic	lb.	5.80	—	5.90
Amyl acetate	gal.	4.00	—	4.25
Arsenic, white	lb.	.18	—	.19
Arsenic, red	lb.	.30	—	.60
Barium chloride	ton	80.00	—	90.00
Barium sulphate (Blanc Fixe, powder)	lb.	.04	—	.04 1/2
Barium nitrate	lb.	.11	—	.11 1/2
Barium peroxide, 80 per cent	lb.	.27	—	.27 1/2

Bleaching powder, 35 per cent chlorine.	lb.	.02	—	.02½
Borax, crystals, sacks.	lb.	.08	—	.08½
Brimstone, crude.	ton	45.00	—	—
Bromine, technical.	lb.	.80	—	.90
Calcium, acetate, crude.	lb.	.03	—	.03½
Calcium, carbide.	ton	80.00	—	90.00
Calcium chloride, 70-75 per cent, fused, lump.	ton	28.00	—	28.00
Calcium peroxide.	lb.	1.80	—	1.90
Calcium phosphate.	lb.	.30	—	1.31
Calcium sulphate.	lb.	.01	—	.02
Carbon bisulphide.	lb.	.04½	—	.04½
Carbon tetrachloride, drums.	lb.	15½	—	.16
Caustic potash, 88-92 per cent.	lb.	.85	—	.86
Caustic soda, 76 per cent.	100 lb.	6.40	—	6.45
Chlorine, liquid.	lb.	.15	—	.18
Cobalt oxide.	lb.	1.55	—	1.60
Copperas.	100 lb.	1.05	—	1.10
Copper carbonate.	lb.	.33	—	.35
Copper cyanide.	lb.	.72	—	.74
Copper sulphate, 99 per cent, large crystals.	lb.	.01½	—	.10
Cream of tartar, crystals.	lb.	.48	—	.49
Epsom salt, bags.	100 lb.	4.25	—	4.50
Formaldehyde, 40 per cent.	lb.	.17	—	.18
Glauber's salt.	100 lb.	.65	—	.70
Glycerine, bulk, C. P.	lb.	.61	—	.62
Iodine, resublimed.	lb.	3.50	—	.04
Iron oxide.	lb.	.02	—	.04
Lead, acetate, white crystals.	lb.	.16	—	.17
Lead arsenate.	lb.	.12½	—	.13½
Lead nitrate.	lb.	.17	—	.18
Lead oxide.	lb.	.08	—	.10
Lithium carbonate.	lb.	1.02	—	1.05
Manganese dioxide, U. S. P.	lb.	.55	—	.60
Magnesium carbonate, tech.	lb.	.13	—	.14
Nickel salt, single.	lb.	.14	—	.14½
Nickel salt, double.	lb.	.11	—	.12
Phosphorus, red.	lb.	1.12	—	1.15
Phosphorus, yellow.	lb.	1.25	—	1.30
Potassium bichromate.	lb.	.55	—	.56
Potassium bromide granular.	lb.	1.09	—	1.05
Potassium carbonate calcined, 80-85 per cent.	lb.	.60	—	.70
Potassium chlorate, crystals.	lb.	.56	—	.57
Potassium cyanide, 98-99 per cent.	lb.	2.15	—	2.20
Potassium iodide.	lb.	2.90	—	2.92
Potassium muriate 80-85 p. c. basis of 80 p. c.	ton	375.00	—	400.00
Potassium nitrate.	lb.	.30	—	.34
Potassium permanganate.	lb.	4.00	—	4.10
Potassium prussiate, red.	lb.	2.60	—	2.70
Potassium prussiate, yellow.	lb.	.96	—	1.05
Potassium sulphate, 90-95 p. c. basis 90 p. c.	ton	350.00	—	375.00
Rochelle salts.	lb.	.37½	—	.38½
Salt ammoniac, gray gran.	lb.	.11	—	.12
Salt ammoniac, white gran.	lb.	.17	—	.18
Salt soda.	100 lb.	1.10	—	1.20
Salt cake.	100 lb.	.90	—	1.00
Silver cyanide.	oz.	.70	—	.70
Silver nitrate.	oz.	.46½	—	.48
Soda ash, 58 per cent, light, flat.	100 lb.	2.80	—	3.00
Soda ash, 58 per cent, dense, flat.	100 lb.	3.90	—	4.00
Sodium acetate.	lb.	.02	—	.10
Sodium benzoate.	lb.	5.00	—	5.50
Sodium bicarbonate, domestic.	100 lb.	2.10	—	2.20
Sodium bicarbonate, English.	lb.	.15	—	.15½
Sodium bisulphate, powder.	lb.	.03½	—	.04
Sodium chlorate.	lb.	.212½	—	.25
Sodium cyanide.	lb.	.70	—	.75
Sodium fluoride, commercial.	lb.	.13	—	.14
Sodium hyposulphite.	lb.	.01¾	—	.02
Sodium nitrate, refined.	lb.	.05½	—	.05¾
Sodium nitrite.	lb.	.39	—	.43
Sodium peroxide.	lb.	.90	—	.95
Sodium phosphate (tri).	lb.	.01½	—	.01¾
Sodium prussiate, yellow.	lb.	.30	—	.31
Sodium silicate, liquid—40 deg. Baume.	100 lb.	1.50	—	1.60
Sodium sulphate, 80 per cent crystals.	lb.	1.55	—	1.70
Sodium sulphate, 60 per cent, fused.	100 lb.	2.60	—	3.01
Sodium sulphite.	lb.	.03¼	—	.03½
Strontium nitrate.	lb.	.28	—	.30
Sulphur chloride, drums.	lb.	.06	—	.01½
Sulphur dioxide, liquid, in cylinders.	lb.	.12	—	.14
Sulphur, flowers, sublimed.	100 lb.	3.20	—	3.30
Sulphur, roll.	100 lb.	2.55	—	2.60
Sulphur, crude.	ton	45.00	—	46.00
Tin bichloride, 50 deg.	lb.	.19½	—	.20
Tin oxide.	lb.	.66	—	.70
Tungstic acid, basis 100 per cent.	lb.	1.40	—	1.50
Zinc carbonate.	lb.	.25	—	.27
Zinc chloride.	lb.	.10½	—	.11
Zinc cyanide.	lb.	.50	—	.50
Zinc dust, 350 mesh.	lb.	.18	—	.20
Zinc oxide, American process XX.	lb.	.17	—	.20
Zinc sulphate.	lb.	.06	—	.05½

Coal Tar Products (Crude)

Benzol, pure, water white.	gal.	.55	—	.60
Benzol, 90 per cent.	gal.	.57	—	.59
Toluol, pure, water white.	gal.	1.90	—	2.00
Xylol, pure, water white.	gal.	.50	—	.55
Solvent naphtha, water white.	gal.	.17	—	.20
Solvent naphtha, crude, heavy.	gal.	.13	—	.14
Cresote oil, 25 per cent.	gal.	.51	—	.53
Dip oil, 20 per cent.	gal.	.22	—	.30
Fitch, various grades.	ton	8.00	—	20.00
Carbolic acid, crude, 95-97 per cent.	lb.	1.05	—	1.10
Carbolic acid, crude, 50 per cent.	lb.	.65	—	.60
Carbolic acid, crude, 25 per cent.	lb.	.40	—	.32
Cresol, U. S. P.	lb.	.25	—	—

Intermediates, Etc.

Alpha naphthylamine.	lb.	.90	—	1.05
Aniline oil.	lb.	.29	—	.31
Aniline salts.	lb.	.34	—	.35
Aniline, 80 per cent.	lb.	.10	—	.10
Benzaldehyde.	lb.	4.50	—	5.00
Benzidine, base.	lb.	1.85	—	2.00
Benzil fine, sulphate.	lb.	1.65	—	1.70
Benzoic acid.	lb.	5.50	—	7.00

Benzyl chloride.	lb.	2.00	—	2.10
Beta naphthol benzoate.	lb.	14.00	—	16.00
Beta naphthol, sublimed.	lb.	.70	—	.75
Beta naphthylamine, c.m.	lb.	2.50	—	2.60
Dichlor benzol.	lb.	.22	—	.23
Dinitrochlorbenzol.	lb.	.46	—	.48
Dimethylamine.	lb.	.55	—	.60
Diphenylamine.	lb.	.95	—	1.00
H-acid.	lb.	3.25	—	3.50
Metaphenylenediamine.	lb.	1.60	—	1.65
Monochlorbenzol.	lb.	.28	—	.32
Naphthalene, flake.	lb.	.09½	—	.10
Naphthionic acid, crude.	lb.	1.50	—	1.75
Nitro naphthalene.	lb.	.45	—	.50
Nitro toluol, light.	lb.	.55	—	.60
Ortho-aminophenol.	lb.	1.00	—	1.15
Ortho-toluidine.	lb.	5.00	—	6.00
Para-aminophenol, base.	lb.	3.50	—	3.75
Paranitrophenol.	lb.	1.90	—	2.00
Paraphenylenediamine.	lb.	.40	—	.42
Para-toluidine.	lb.	8.00	—	9.00
Phenol, U. S. P.	lb.	16.00	—	17.00
Resorcin, technical.	lb.	1.15	—	1.20
Resorcin, pure.	lb.	1.70	—	1.75
Saleylic acid.	lb.	.61	—	.63
Salol.	lb.	3.00	—	3.33
Sulphanilic acid.	lb.	.80	—	.85
Tolidin.	lb.	—	—	—
Toluidine-mixture.	lb.	—	—	—

Petroleum Oils

Crude (at the Wells)

Pennsylvania.	bbl.	3.10	—	—
Corning, Ohio.	bbl.	2.40	—	—
Somerset, Ky.	bbl.	2.15	—	—
Waco, Ohio.	bbl.	2.18	—	—
Indiana.	bbl.	1.78	—	—
Illinois.	bbl.	1.92	—	—
Oklahoma and Kansas.	bbl.	1.90	—	—
Caddo, La., light.	bbl.	1.90	—	—
Corsicana, Tex., light.	bbl.	1.70	—	—
California.	bbl.	1.78	—	.87
Gulf Coast.	bbl.	1.00	—	—

Lubricants

Black, reduced, 29 gravity, 25-30 cold test.	gal.	13½	—	.14
Cylinder, light.	gal.	.21	—	.26
Cylinder, dark.	gal.	.18	—	.19
Paraffine, high viscosity.	gal.	29½	—	.30
Paraffine, 303 sp. gr.	gal.	21½	—	.22
Paraffine, 365 sp. gr.	gal.	18½	—	.19

Flotation Oils

(Prices at New York)

Pine oil, steam distilled, sp. gr. 0.925-0.940.	gal.	.52	—	—
Pine oil, destructively distilled, sp. gr. 0.920-0.940.	gal.	.48	—	—
Pine-tar oil, sp. gr. 1.025-1.035.	gal.	.25½	—	—
Pine-tar oil, double refined, sp. gr. 0.965-0.990.	gal.	.35	—	—
Pine oil, light, sp. gr. 0.950, tank cars, f.o.b. works.	gal.	.37	—	—
Pine oil, heavy, sp. gr. 1.025, tank cars, f.o.b. works.	gal.	.26	—	—
Pine tar, thin, sp. gr. 1.060-1.080.	gal.	.22	—	—
Turpentine, crude, sp. gr. 0.980-1.000.	gal.	.40	—	—
Hardwood oil, f.o.b. Michigan, sp. gr. 0.960-0.990.	gal.	.19	—	—
Hardwood oil, f.o.b. Michigan, sp. gr. 1.06-1.08.	gal.	.19	—	—

Vegetable and Other Oils

China wood oil.	lb.	.16	—	.16½
Cottseed oil, crude.	gal.	1.11	—	—
Linseed oil, raw, cars.	gal.	1.20	—	—
Peanut oil, crude.	gal.	1.15	—	—
Rosin oil, first run.	gal.	.38	—	—
Rosin oil, fourth run.	gal.	.67	—	—
Soya bean oil, Manchuria.	lb.	14½	—	—
Turpentine, spirits.	gal.	.49	—	—

Miscellaneous Materials

Barytes, floated, white, foreign.	ton	38.00	—	40.00
Barytes, floated, white, domestic.	ton	28.00	—	32.00
Beeswax, white, pure.	lb.	.55	—	.60
Carnauba wax, dor.	lb.	.51	—	—
Casin.	lb.	.19	—	.28
Chalk, light, precipitated, English.	lb.	.03	—	.06
Feldspar.	ton	8.00	—	12.00
Fuller's earth, powdered.	100 lb.	1.00	—	1.50
Ozokerite, crude, brown.	lb.	.60	—	.70
Ozokerite, American.	lb.	.35	—	—
Red lead, dry, carloads.	lb.	.12	—	—
Rosin, 280 lb.	bbl.	6.40	—	—
Scapstone.	ton	10.00	—	12.50
Talc, American, white.	ton	10.00	—	13.00
White lead, dry.	lb.	.10½	—	—

Refractories, Etc.

(F.O.B. Works)

Chrome brick.	net ton	Nominal	—	—
Chrome cement, Grecian.	net ton	60.00	—	—
Clay brick 1st quality fireclay.	per 1000	45.00	—	—
Clay brick, second quality.	per 1000	40.00	—	—
Magnesite, raw.	ton	30.00	—	35.00
Magnesite, calcined.	ton	40.00	—	55.00
Magnesite, Grecian, dead burned.	net ton	90.00	—	—
Magnesia brick, Grecian, 9x4½x2½.	net ton	140.00	—	—
Silica brick.	per 1000	45.00	—	—

Ferroalloys

Ferrochromium.	lb.	Nominal	—	—
Ferromanganese, domestic, delivered.	ton	425.00	—	450.00
Ferromanganese, English.	ton	200.00	—	—
Ferrosilicium, 50 per cent, of Mo.	lb.	4.25	—	—
Ferrosilicon, 50 per cent, carloads, del., Pittsburgh.	ton	240.00	—	250.00
Ferrosilicon, 50 per cent, f.o.b. Pittsburgh.	ton	100.00	—	—
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh.	lb.	2.00	—	—
Ferrosulphur, f.o.b. works.	lb.	3.25	—	3.50

INDUSTRIAL

Financial, Construction and Manufacturers' News

Financial

New Companies

Argus Mining Company, Sandpoint, Idaho, has been incorporated with capital of \$800,000, and L. E. Myers, G. B. Hoyt, W. D. Boyce, incorporators, to buy, sell and lease mining property, coal and timber lands, operate sawmills, power plants and smelters.

Azadon Corporation has been incorporated with a capital of \$150,000 to acquire and market petroleum. The incorporators are F. D. Buck, M. L. Harty, K. E. Longfield, Wilmington, Del.

Bassick Company, Bridgeport, Conn., has been incorporated with a capital of \$6,000,000 to manufacture iron and steel, copper, wood and other material.

The Bellwood Foundry & Machine Company, Bellwood, Pa., has been incorporated with a capital of \$20,000. Geo. C. Bland of Tipton, Inc., incorporator.

B. Brown & Bro., Inc., New York City, has been incorporated with a capital of \$100,000 to deal in and manufacture oils, chemicals and colors. The incorporators are J. C. Brown, J. R. Bernstein, I. Skutch, 998 Sterling Place, Brooklyn.

California Burdett Oxygen Company has been incorporated with a capital of \$500,000 to manufacture oxygen, hydrogen and other gases. The incorporators are H. E. Latter, H. M. Robinson, C. M. Egner, Elkton, Md.

Central Glass Company, Delaware, has been incorporated with a capital of \$1,000,000 to manufacture glass of all kinds. The incorporators are H. E. Latter, C. H. Rimplinger, C. M. Egner, local Wilmington incorporators.

Chemical Securities Company has been incorporated in Delaware with \$750,000 capital. Will conduct an investment business.

Commercial Iron & Steel Corporation, Delaware, has been incorporated with 1000 shares of no par value. J. R. Munoz, representative, 115 Broadway, New York.

The Corrugated Fibre Mills, Inc., Brooklyn, N. Y., has filed articles of incorporation with capital of \$100,000 to manufacture paper corrugated and fiber board. J. B. Colan, L. Levine and J. C. Bassett, 27 Pine Street, New York, are the incorporators.

The DeWand Chemical Company, Newark, N. J., has filed articles of incorporation with capital of \$25,000 to manufacture chemicals. The incorporators are Nathaniel A. Clinger, William G. Andur and William H. Reardon.

J. E. Dockendorff & Co., Inc., New York, has been incorporated with a capital of \$500,000 to manufacture iron, steel, copper and wood articles. The incorporators are J. E. Dockendorff, R. A. Young, J. R. Clark, Jr., 120 Broadway.

The Dodge-Veldon Iron Company, 15 Exchange Place, Jersey City, N. J., has filed articles of incorporation with capital of \$510,000, to operate mining properties. The incorporators are: Andrew L. Meyer, 222 West 145th Street, New York, and Harry Oshroff, 1230 Fulton Avenue, Brooklyn; Joseph F. Simpson, 440 Riverside Drive, New York.

Elliott-Blair Steel Company, Pittsburgh, Pa., has been incorporated with a capital of \$1,000,000 to deal in steel. The incorporators are George D. Blair, N. W. Elliott, Thomas C. Elliott, New Castle.

Fine Colors Company, Van Houten Street, Paterson, has been incorporated with a capital of \$300,000 to manufacture lake and pigment colors.

Fish Products Company, Inc., New York, has been incorporated with a capital of \$200,000 to manufacture oils and fertilizing materials. The incorporators are F. Seligman, W. G. Weichmann, A. Juretzki, Jr.

Gasoline Oil Refining Company, New York, has been incorporated with a capital of \$1,000,000. The incorporators are

Allen E. Moore, George F. Jebbett, F. H. Buehner, of New York.

The International Marine Welding Company, Dover, Del., has been incorporated with capital of \$200,000 by New Jersey interests to operate a welding plant to specialize in marine work. The incorporators are Charles R. Stewart, Roy T. Anderson, Ridgewood, N. J., and David H. Wilson, Jr., Brooklyn, N. Y.

The Jaffrey Manufacturing Company, Trenton, N. J., has been incorporated with a capital of \$50,000 to manufacture chemicals. The incorporators are Benjamin D. Phillips, New York; Harry H. Umberger, and L. E. Conover, both of Trenton.

Kellogg Products Company, Inc., Buffalo, N. Y., has been incorporated with a capital of \$2,500,000 to manufacture margarine, vegetable oils, soaps, glycerol and chemicals. The incorporators are S. Kellogg, S. Kellogg, Jr., and H. Kellogg, Buffalo.

Keystone Iron & Steel Works, Los Angeles, Cal., has been incorporated with a capital of \$500,000. The incorporators are J. E. Geyer, W. S. McGiffert, A. A. Barton, J. L. Loftus and W. F. Allen.

The Koal-Oak Fuel Company, Fresno, Cal., has been incorporated with a capital of \$200,000.

The Lincoln Brass Foundry Company, Chester, Pa., has been organized to operate a local brass foundry. F. W. Mathews, Swarthmore, is the principal incorporator.

Long Fire Mining Company, Ogden, Utah, has been incorporated with a capital of \$50,000. The incorporators are J. S. Lewis, G. W. Williams, F. Melsner, J. S. Lewis.

The Loxol Manufacturing Company, Lebanon, Pa., has been incorporated with a capital of \$100,000 to manufacture cement, paint, polish, insulators, spark plugs and kindred products. The incorporators are E. L. Gledhill, J. D. Demers, P. A. Painchaud, T. J. West, Jr., and A. O. Painchaud.

Lutz Chemical Corporation, New York, has been incorporated with a capital of \$1,000,000 to deal in drugs, chemicals, etc. The incorporators are D. A. Lutz, A. Brandt, Emil Tucker.

Manila Copper Mining & Smelting Co., Spokane, Wash., has been incorporated with a capital of \$2,600,000. The incorporators are H. Ostrander, H. W. Lefevre, T. J. Neely, L. P. Edge and F. L. Middleton.

The Manufacturers Iron & Steel Company, New Brunswick, N. J., has been incorporated with a capital of \$8,000,000 to manufacture iron and steel products. The company will take over and operate the plant of the Navesink Manufacturing Company, New Brunswick, manufacturer of horseshoes and calks, as well as the plant of the Hyden Horseshoe Company, Cataugua, Pa. The incorporators are James W. Johnson, William J. McCurdy and Robert C. Nicholas.

The Merigold Electro-Plating Company, Newark, N. J., has been incorporated with a capital of \$100,000 to operate a plant at 97 E. Chestnut Street. The incorporators are John L. Merigold, L. M. and Oliver J. Sizelove.

The Nassau Smelting & Refining Works, 602 West 57th Street, New York City, has filed articles of incorporation with capital of \$1,000,000 to specialize in the production of materials for foundry use and in the refining and casting of all other metals. The incorporators are C. B. Zabriskie, 115 East Nineteenth Street; H. L. St. John, 270 Riverside Drive, and A. E. Beggs, 876 Carroll Street, Brooklyn.

Norwich-Pacific Copper Company, Delaware, has been incorporated with a capital of \$60,500,000 to do general mining, milling, refining and marketing of copper, lead, zinc, gold, silver and all other ores and metals. The incorporators are A. W. Britton, S. B. Howard, L. H. Gunther, H. B. Davis, Jos. F. Curtis, all of New York.

Northern Graphite Corporation, New York City, has been incorporated with a capital of \$250,000 to do mining, milling, concen-

trating ores, etc. The incorporators are G. A. Alonzo, S. Banome, R. Loudon, 2 Rector Street.

The Northwest Magnesite Company, 607 Hutton Building, Spokane, Wash., was incorporated May 10, 1917, with a capital of \$1,000,000. The incorporators are B. L. Thane, R. E. Adams, R. S. Talbot and Scabury Merritt. The officers are R. S. Talbot, president; S. F. B. Morse, vice-president; B. L. Thane, consulting engineer; Scabury Merritt, secretary, and D. J. Neer, treasurer. The company's properties are located about 6 miles from Chewelah, a town on the Great Northern Railroad, situated about 60 miles north of Spokane. Operations were commenced in November, 1916, and about 4000 tons have been shipped. The company will build either a narrow-gauge railroad or aerial tramway to the properties. Two rotary kilns, 125 ft. long and 7 ft. 6 in. in diameter are now being installed for calcining the raw magnesite. The capacity of the plant will be about 4500 tons per month.

The Nu Process Gasoline Company, Dover, Del., has been incorporated with a capital of \$300,000 to manufacture refined oils. Robert McKnight, F. Neepser and M. Neepser, all of Pittsburgh, are the incorporators.

Owens & Phillips, Inc., New York, has been incorporated with a capital of \$150,000 to deal in chemicals and fire-extinguishing compounds. The incorporators are A. R. Latson, Jr., T. E. Smith, E. L. Tamblin, 424 First Street.

Phenix Sulphur Corp., Delaware, has been incorporated with a capital of \$1,000,000 to mine for and deal in sulfur, gypsum, etc. The incorporators are M. Egner, H. E. Latter, H. M. Robertson, of Wilmington, Del.

The Allen W. Phillips Smelting Company, Attleboro, Mass., has been incorporated with a capital of \$50,000. The incorporators are A. W. Phillips, Charles Bloss, Dr. Louis Millet, Thomas G. Sadler.

Quaker-Hill Blue Lead Mining Company, Delaware, has been incorporated with a capital of \$3,500,000, to acquire mines and conduct general mining business. The incorporators are H. E. Latter, C. L. Rimplinger, C. M. Egner, Wilmington, Del.

The Quito River Mining & Dredging Company has been incorporated by Robert L. DeGoff and associates in Delaware with capital of \$500,000, to operate mining properties. Other incorporators are S. Voodhall, West Orange, N. J., and Roswell S. Nichols, Westfield, N. J.

Reslow Chemical Company, Newark, N. J., has been incorporated with a capital of \$1,000,000 to manufacture and deal in chemicals and drugs. The incorporators are E. P. Scheck, L. Fisher, L. A. Mills, Montclair.

The Rush Chemical Company, Pittsburgh, Pa., has been incorporated with a capital of \$100,000 to manufacture chemicals, etc. The incorporators are Arthur E. Young, B. Ratcliffe, N. N. Hackett, Grant Curry and E. D. Young, all of Pittsburgh.

Schoen-Jackson Steel Company, Pittsburgh, Pa., has been incorporated with a capital of \$500,000 to deal in iron and steel. The incorporators are A. R. Bassett, W. H. Schoen, M. R. Jackson.

The Superior Iron & Steel Corporation has been incorporated in Dover, Del., with a capital of \$3,000,000 to manufacture iron and steel products. The incorporators are Horace L. Easton, J. W. Smith and M. E. Doto, all of Wilmington.

Texas Chemical Company, Houston, Tex., has been incorporated with a capital of \$100,000. The incorporators are E. F. Howard and E. D. Chad E. Howard, and S. Poiser of San Francisco.

Thor Steel Corp., New York City, has been incorporated with a capital of \$100,000 to operate steel mills. The incorporators are H. Van Arsdale, Jr., L. A. Watson, C. J. Kulberg.

The Tottenville Copper Company, Inc., Richmond, Staten Island, has been incorporated with a capital of \$1,000,000 to operate smelting and refining works. The company has its plant and office on Church Street, Tottenville. B. Lowenstein and I. Livingston are the incorporators.

Tucker-Watney Corporation, New York, has been incorporated with a capital of \$100,000 to operate steel mills. The incorporators are C. J. Kulberg, L. A. Watson, H. Van Arsdale.

United States Metals Refining Corporation, Inc., New York, has been incorporated with a capital of \$4,000,000 to develop mines. Representative, F. Y. Robertson, 120 Broadway.

The United States Magnesite Company, Cheekane, has been incorporated to work deposits in the magnesite district of Stevens County. The company has capital stock of

\$100,000, and incorporators are Charles P. Oudin and Charles V. Bob. This is the third concern organized for mining magnesia in Stevens County.

The Universal Pipe Line Oil & Producing Co., Delaware, has been incorporated with a capital of \$5,000,000 to erect refineries of all kinds. The incorporators are F. D. Buck, M. L. Horth, J. D. Frock.

Universal Rubber Fiber Company, New York, has been incorporated with capital of \$10,000,000 to chemically compound and treat greases and growths of fibrous and kindred nature. The incorporators are C. Madden, Hiram Cavanaugh, F. H. Coulson, all of New York.

The Utility By-Products Chemical Co., 790 Broad Street, Newark, N. J., has been incorporated with a capital of \$50,000 to manufacture chemicals.

Virginia & Ohio Manufacturing Company, Wilmington, Del., has been incorporated with a capital of \$50,000. The incorporators are Herbert B. Latzer, C. L. Hunsinger, Clement M. Egner, Wilmington.

Vulcan Iron & Steel Company, Paden City, W. Va., has been incorporated with a capital of \$300,000. The incorporators are Thomas Watson, George R. Wallace, E. B. Fowler, S. L. Connelly, and W. B. Dichealey, all of Pittsburgh, Pa.

Warner-Caldwell Oil Co., Delaware, has been incorporated with a capital of \$1,000,000 to mine and bore for petroleum and natural gas. The incorporators are H. E. Latzer, C. L. Rimlinger, C. N. Egner.

The Washington Mold Machine & Foundry Company, Washington, Pa., has been incorporated with a capital of \$25,000 to operate a local plant. Charles Bromley is the principal incorporator.

Wasson Securities Corporation, New York, has been incorporated with a capital of \$362,300 to manufacture iron and steel. The incorporators are M. M. McMahon, L. L. Rohr, A. C. Connelly, 5 Nassau Street.

The Waterloo Refining Co., Delaware, has been incorporated with a capital of \$1,250,000 to bore for natural gas, oil, etc., and market and refine the same. The incorporators are M. M. McMahon, K. E. Longfield.

Western Producing & Refining Co., Tulsa, Okla., has been incorporated with a capital of \$100,000. The incorporators are C. H. Overton, R. K. Hughes, M. J. McNulty.

Wilbur Mining & Milling Co., Dover, Del., has been incorporated with a capital of \$200,000 to carry on general mining, milling and refining business. The incorporators are L. B. Phillips, J. B. Bailey.

Wilde & Co., Boston, Mass., has been incorporated with a capital of \$25,000. The incorporators are F. P. Ellis, Brookline; Charles Perkins, Chicago; W. H. Nash, Boston.

Wildwoods Oil & Sulphur Co., Wilmington, Del., has been incorporated with a capital of \$100,000. The incorporators are F. O'Keefe, George G. Steigler, E. E. Wright of Wilmington, Del.

The Williams & Crowell Color Co., Providence, R. I., has been incorporated with a capital of \$200,000 to manufacture and deal in dyes and colors. The incorporators are Joseph R. Williams of Pawtucket, H. H. Crowell of Sterling, Conn., and Edwin Knowles of Providence.

Wyoming United Oil Refining Company, Chicago, has been incorporated with a capital of \$3,000,000 to bore for oil, produce and dispose of petroleum and its products. The incorporators are J. A. Maslen, M. M. Hunt, all of Chicago.

Capital Increases, Etc.

The Consolidated Motors Corporation of Philadelphia, a Delaware corporation, has increased its capital from \$1,500,000 to \$2,500,000 for expansion.

The National Folding Box & Paper Company, 132 Franklin Street, New York, has increased its capital from \$1,000,000 to \$2,000,000 for expansion.

The Perkins Foundry Company, Amherst, N. Y., has increased its capital from \$20,000 to \$50,000 for extensions.

The Crystal Chemical Company, Bronx (New York City), N. Y., has increased its capital from \$100,000 to \$200,000 for expansion.

The National Fuel Gas Company, 26 Broadway, New York, a New Jersey corporation, has filed notice of increase in capital from \$16,000,000 to \$32,000,000 for expansion.

The Oliver Chemical Company, Trenton, N. J., with registered office at Perth Amboy, has increased its capital from \$10,000 to \$125,000 to provide for business extensions.

The New Jersey Paper Tube Company, Northhoff, N. J., has increased its capital

from \$25,000 to \$90,000 for expansion. Louis S. Coe, president.

The Tennessee Chemical Company has applied for a capital increase from \$200,000 to \$1,000,000.

The Ohio Steel Products Company, Mineral Ridge, Ohio, has increased its capital stock from \$70,000 to \$100,000.

The Jackson Furnace & Foundry Company, Jackson, Mich., has increased its capital stock from \$20,000 to \$70,000.

The Macbeth-Evans Glass Company has increased its capital stock from \$2,000,000 to \$5,000,000 for extensions and improvements.

States Chemical Company, Chicago, has increased its capital to \$25,000 from \$2,500.

Construction and Operation California

SAN FRANCISCO.—The paint and varnish works of the Bass-Hueter Point Company is being enlarged by the addition of a three-story building.

SAN FRANCISCO.—The Pacific Coast Steel Company is contemplating moving from San Francisco to Oakland. The reason given for this is that better transportation facilities are provided in Oakland than in San Francisco. The company is considering constructing a large factory in Oakland to take the place of the one it now occupies.

SAN FRANCISCO.—A large plant for the manufacture of citric acid is planned by a group of big retail druggists. It is planned to use culls of oranges and lemons to manufacture the acid and other basic chemicals. The California Pharmaceutical Association is interested in the project.

SAN FRANCISCO.—The Tulare Mining Company is opening up a dolomite mine about four miles east of Coleville. The company will install kilns and other apparatus for the preparation of calined products.

Connecticut

NEW LONDON.—The Standard Brass & Copper Tube Company will erect an addition to its plant at this place. The company is a subsidiary of the Bridgeport Brass Company.

Idaho

KELOGG.—The Bunker Hill & Sullivan Mining Company, Frederick W. Bradley, president, will build an electrolytic zinc plant at Kellogg, Idaho; initial capacity 30 tons of ore per day. The lead smelter just being completed by this company will be ready for operation June 1, and at least one stack will be blown in before that date. Coke for the plant will be obtained from the Pacific Improvement Company of Carbonado, Wash., which will start construction of new coke ovens at once. Lime will be obtained from the company's quarries at Lone, Wash.

Indiana

FORT WAYNE.—The Huntington Steel Foundry Company will build a two-story addition to its plant on Condit Street.

Maine

BANGOR.—The Great Northern Paper Company has purchased from the Northern Finance Company water rights, land and other privileges on the Penobscot River. The Great Northern Company plans eventually to build a pulp mill and dam at this place.

Massachusetts

NEW BEDFORD.—The Taunton-New Bedford Copper Company has obtained a permit to build a brick rolling mill and machine shop which will cost \$200,000.

Michigan

RAY CITY.—The Reoller Foundry Company has completed an addition to its plant, including a new cupola capable of melting 15 tons of iron per hour. The company makes iron, aluminum and brass castings.

Missouri

ST. LOUIS.—The Standard Oil Company plans an addition to its Woodriver refinery which will cost about \$2,000,000.

Montana

ANACONDA.—The Washoe and Great Falls Smelters of the Anaconda Mining Company produced 29,300,000 lb. of copper for the month of April as against 31,300,000 lb. for March. The smelting output is due to mine fires, which curtailed production. It

is estimated that the yearly production will total 360,000,000 lb.

HELENA.—The American Smelting & Refining Company has taken over under a bond and lease on a royalty basis, the Sour Dough group of seven mining claims in the Elkhorn District of Jefferson County. Contract provides that the company must use out not less than 100 tons of ore a day. The smelting company desired the ore for the iron silicate contained, to be used for fluxing purposes. At present the smelting material is being shipped to the East Helena smelter is shipped from Utah.

Nevada

CARSON CITY.—Benjamin Q. P. Foss of Philadelphia is planning a \$75,000 plant near here to produce alcohol from Nevada sagebrush.

New Jersey

BAYONNE.—The Texas Company has filed plans for the erection of a series of one-story additions to its plant at First Avenue and Avenue A. The work will include a new converter house, experimental plants, and asphalt shop, and will cost about \$16,000.

CAMDEN.—The Lambert & Todd Machine Company, manufacturer of special machinery, will build a two-story addition to its plant on Arch Street. It is proposed to double the capacity of the plant.

HOBOKEN.—M. J. Kearney is planning to increase the capacity of his copper works at 1206 Clinton Street with the removal of his present building. New York City shops on Twenty-eighth Street to the local plant.

HOBOKEN.—Fire, May 31, destroyed the two-story plant of the Hibbe Chemical Works, Jefferson Street, with loss estimated at \$100,000.

JERSEY CITY.—The Jersey City Cutting & Welding Company, 224 Monmouth Street, has been organized to operate a local plant. John G. Lowe and Christopher Spence are heads of the business.

JERSEY CITY.—The Standard Motor Construction Company, manufacturer of marine and gasoline engines, will build a one-story addition on Whifton Street.

JERSEY CITY.—The Goldschmidt Thermit Company, manufacturer of welding apparatus, is planning for the erection of a one-story addition on Bishop Street to cost about \$10,000.

LINDEN.—The Grasselli Chemical Company, whose head office is Cleveland, Ohio, has been granted a permit to erect a new building here. The new structure will cost about \$36,000 and will be built of brick and steel construction.

NEWARK.—Fire, on May 26, destroyed a portion of the brass foundry of C. A. Goldsmith, 44 Cutler Street.

NEWARK.—The Verona Chemical Company, Verona and Riverside Avenues, has filed plans for the erection of a one-story addition, about 25 x 50 ft.

NEWARK.—Kraetzer & Company, Inc., 553 Eighteenth Avenue, manufacturer of tools, has filed plans for the erection of a new tool shop and steel works on Nye Avenue, Irvington, to cost \$42,000.

NEWARK.—The Block Chemical Works has filed plans for the erection of a one-story addition on Vesey Street.

NEWARK.—The O. W. Young's Oils, Inc., has leased a two-story building at 33 Ross Street, Newark, and will use same for the refining of oils, greases, lubricants, etc.

TRENTON.—The Delton Tire & Rubber Company has awarded contracts for the erection of two new reinforced-concrete additions to its plant on Third Street, to cost about \$17,000. The structures will be 50 x 110 ft. and 25 x 65 ft.

New York

BUFFALO.—The McDougall Paint Company has leased the property formerly occupied by the Peter J. Kellogg Manufacturing Company at Water and Norton Streets. After making extensive alterations, the McDougall Paint Company will occupy the property.

BUFFALO.—The Kellogg Products Company, a new \$2,500,000 corporation, has purchased the plant formerly occupied by the Buffalo Paint & Varnish Company and the Certainteed Products Company. The directors of the new company are Spencer Kellogg, Jr., Spencer Kellogg, Sr., Howard Kellogg, E. H. Stichel and J. C. Aikman. The company will manufacture margarine, soap, glycerine, edible products and other chemicals. The general offices of the company will be in the Kellogg Building at 98 Delaware Avenue.

CARTHAGE.—The Carthage Sulphite Pulp & Paper Company has purchased additional property for extension of its mills.

North Carolina

NEW BERN.—The New Bern Cotton Oil Mill Company is erecting an addition to its plant on Griffith Street.

Ohio

ALLENDALE.—The Postoria Pressed Steel Company, incorporated with a capital of \$100,000, will make pressed steel parts for the Allen Motor Company. The plant will turn out complete sheet metal products, including enameling and japanning. The company's new plant will have 20,000 sq. ft. of floor space.

HAMILTON.—The plant of the Hamilton Furnace Company at Cokeotto was recently opened after having been closed for almost ten years.

Oregon

PORTLAND.—The Potato Starch Manufacturing Company has been incorporated by Portland capital, headed by J. F. Griffith, and the construction of a starch plant near Portland, to be followed later by other plants in the Willamette Valley. The "cull" potatoes will be used in manufacturing the starch, and initial plant will have capacity of 20 tons daily, turning out four tons of starch, besides valuable by-products.

Pennsylvania

PHILADELPHIA.—The Gill Glass Company will erect a three-story, reinforced concrete and brick factory which will cost \$200,000.

PHILADELPHIA.—The Philadelphia Paper Manufacturing Company will erect a one-story brick factory building at Nixon road of Fountain Street, costing \$75,000.

PHILADELPHIA.—The John Lang Paper Company will erect a five-story addition to the plant here at a cost of \$40,000.

Utah

MORONI.—The new sugar plant now under construction here by the People's Sugar Company is expected to be ready to begin operation by October 1. The managers expect to handle 50,000 tons of beets this season. The plant contains the most modern machinery for the production of sugar from beets.

SALT LAKE CITY.—It is reported that the Mineral Products Company is producing 100 to 150 lb. of potash and 300 to 350 lb. of alumina from one ton of rock. A considerable quantity of sulphuric acid is also produced as a by-product.

Washington

ANACORTES.—C. H. Freeman of this city plans immediate development of his molybdenite mining claims near this city, and establishment of concentrate mills. Assays show claims have average run of \$50 per ton. Washington Molybdenite Company has been organized, with C. H. Freeman, president, Herman Hohde, vice-president.

NORTHPORT.—The Northport Smelting & Refining Company, of which George S. Bailey is manager, will install building and equipment for the Cottrell process of fume recovery. The estimated cost is \$100,000. C. L. Graves is the engineer in charge.

SEATTLE.—Copper ore shipments from Cordova, Alaska, which have been retarded, due to damages to the Copper River & Northwestern Railroad lines by heavy ice jams, will be resumed in the near future. The Tacoma smelter recently received a cargo of 1500 tons of copper ore, which had been mined during the winter and stored in Cordova.

SEATTLE.—The Northwest Lead Company, manufacturers of lead pipe, sheet lead and lead specialties, will remove its plant from Portland, Ore. Seattle, where will occupy a building being remodeled to meet its needs. The plant has a capacity of 25 tons of finished product daily. Much new equipment is to be installed, including a 60-ton sheet lead mill and a lead trap machine weighing 13 tons. Besides above-mentioned products the company will manufacture lead pipe, lead wool, galvanized water and gas mains, glass lead, sash weights and sinkers.

SEATTLE.—The American Nitrogen Products Company, Securities Building, Seattle, has started survey work on its proposed power plant and nitrogen products plant on the Sauk-Suiattle River, in Snohomish County, 60 miles from Seattle. The company expects to have all required work completed by early fall, when plans will be prepared in the local office for the buildings and structures, and construction work will start early next spring. The proposed power plant will cost \$1,000,000, and ultimate development of the project will represent an investment of several million dollars.

The company has a smaller similar plant at La Grande, near Tacoma, which is now producing sodium nitrite. This plant is a preliminary stage toward the large development in Snohomish County. C. P. Graff is president.

SEATTLE.—The Pacific Oils Company, engaged in the manufacture of peanut, soyabean, coconut and other vegetable oils, has leased a seven-acre tract on the Duwamish Waterway and will build a factory costing \$250,000, according to Herman Meyer, secretary and manager of the concern. Site is leased for thirty-five years.

SPOKANE.—The United Gold Mining Company, according to W. W. Robbins, mine superintendent, plans to replace cyanide by flotation in the dressing of ore in the company's mill at its Oregon properties. A flotation plant with capacity of 75 to 100 tons daily will be installed. Tailings will be stacked and treated by cyanide later.

VALLEY.—The American Mineral Production Company's new buildings at Valley, Wash., are being rapidly pushed to completion. Magnesite is being shipped to the Valley at the rate of one car daily, about half being crude, the remainder the calcined product. New oil-burning kilns are being constructed and shipments will soon be largely increased.

Wisconsin

MILWAUKEE.—The Valley Steel Company, a newly organized concern, will erect a steel plant at St. Francis, three miles from the city, located on Lake Michigan. The plant will contain two 60-ton open-hearth furnaces, a 24-in. billet mill and a 10-in. merchant bar mill.

British Columbia

ANYOX. B. C.—The Granby Consolidated Mining, Smelting & Power Company plans to install an experimental plant of 100 tons capacity, using the flotation process, to treat millions of tons of siliceous ore which the company has heretofore not used. If successful, a plant of large capacity will be installed. Operations at the Grand Forks smelters have been interrupted by lack of coke supplies, but the full battery of four furnaces at Anyox are now in operation.

LADYSMITH.—The Ladysmith Smelter, Ladysmith, B. C., is preparing to ship ore and has laid additional trackage at its yards. The smelter itself is practically ready to commence operations, and ore shipments will arrive shortly from various points on the Island and from mines on the British Columbia Coast.

TEXADA ISLAND.—Development of the lime industry on Texada Island, British Columbia, has reached such proportions that the Pacific Lime Company of Vancouver, has taken over a four-masted schooner to carry the product to San Francisco.

TRAIL.—The Consolidated Mining & Smelting Company of Canada, operating a large smelter and appurtenant plants at Trail, B. C., plans to more than double the capacity of its sulphuric acid plant, now producing 12 tons daily. Twenty-four furnaces, each of larger capacity than the furnaces built in the last previous year, will be erected, and extension made to the acid furnace building. The chamber building is also being doubled in size. The initial unit covered an area of 893 sq. ft., built of tile brick and contained two lead chambers and towers. Increase of capacity is necessitated by the demand for sulphuric acid in the copper, lead and zinc refineries.

PRINCE RUPERT.—The Molybdenite Mining & Reduction Company, Prince Rupert, B. C., which owns a large deposit of molybdenite near this city, has built an aerial tram mill and concentrator which will treat 150 tons daily.

Manufacturers' Notes

THE BURDETT OXYGEN COMPANY will open an office in Chattanooga, Tenn., at 410 Market Street, which will be in charge of W. J. Collins, vice president of the company. The Burdett Company has a plant in Chattanooga which works in conjunction with Wilson & Co.

THE DRIVER-HARRIS WIRE COMPANY of Harrisburg, Pa., has filed notice that its name has been changed to Driver-Harris Company. The former name did not comprehensively designate the products of the company, and the wire makes up an important part of its production. It manufactures largely alloys and pure metals in the form of strip, rods, sheets and wire. The company also manufactures flexible heater cords and wire rope.

THE ASBESTOS PROTECTED METAL COMPANY of Pittsburgh announces the temporary closing of its Atlanta and St. Louis offices. This is due to the fact that J. C. Nichols, Atlanta, has been transferred the Officers' Reserve Corps at Fort McPherson, and F. C. Easterby, St. Louis manager, has entered the Officers' Reserve Corps at Fort Riley, Kan. The home office is in the First National Bank Building, Pittsburgh.

EXPORTS OF ORES FROM PERU TO UNITED STATES.—The following table, from Commerce Reports, shows the quantity and value of certain minerals exported from Peru to the United States during the calendar year 1916:

Product	Quantity	Value
Tungsten, kilos	529,860	\$771,041
Vanadium, tons	2,915½	\$29,378
Molybdenum, kilos	4,412	\$,841
Antimony, kilos	63,038	6,130
Tin bars, tons	1	502

*Nominal value.

There are no available official statistics showing the total exportation of these minerals during 1916, but inasmuch as nearly all the minerals were exported to the United States during this period the foregoing table represents practically the total quantity. The tonnage of the total value of 62 per cent concentrates: molybdenum about 90 per cent, and the antimony 53 per cent.

THE CHARLES A. SCHIEREN COMPANY.—New York Manufacturers' Exchange bak waterproof and steamproof leather belting, has recently opened branch offices at 72 Congress Street West, Detroit; 18 South Broadway, St. Louis; 1001 So. Main Street, Memphis; 172 Marietta Street, Atlanta, in addition to those already established at New Orleans, Dallas, Boston, Philadelphia, Pittsburgh, Chicago, Denver and Seattle.

RENNERFELT FURNACES.—Hamilton & Hansell, 17 Battery Place, New York, announce the installation of the following Rennerfelt furnaces: Chill Exploration Co., New York City, 1600 1st Avenue, Central Steel Co., Massillon, Ohio, one-ton for melting ferromanganese.

NEW ASSAYING FIRM IN SALT LAKE CITY.—Under the firm name of Black & Deason, a new assay, assaying and chemical analysis will be opened Monday at 165 South Temple Street. William A. Black was originally an Iowa man, but has spent the last twenty-five years in Salt Lake, being for the last several years manager of the R. H. Officer assaying firm, with which he has been identified seventeen years. B. W. Deason was born at Park City, and has spent the last twelve years in Salt Lake, eleven of them being as chief chemist of the R. H. Officer Company.

CONSERVING THE SUPPLY OF TIN PLATE.—At a recent meeting of the Committee on the Conservation of Tin Plate, held at the Bureau of Foreign and Domestic Commerce, Department of Commerce, it was claimed by certain manufacturers of perishable products that the recommendation by the committee to the wholesale grocers "that they forthwith voluntarily suspend or cancel all contracts for delivery of non-perishable food products in tins, made with canners, and fully relieve the latter from all liability thereunder," would result in grocers canceling unfavorable contracts and suspending others. No evidence of any proposed action of this sort was brought to the attention of the committee, which did not, therefore, feel justified in changing the wording of the clause involved. It was thought advisable, however, to state that the committee, in suggesting the option of cancellation or suspension of contracts, did so with the idea that it might in many cases be mutually agreeable to suspend rather than cancel contracts and that in such cases, suspension would be the better solution. No other point brought out at the meeting was the question of foreign contracts. It was recommended that contracts affecting the military requirements of our Government, and those of our Allies should be given preferred treatment, but that before making deliveries on such contracts manufacturers should make a careful proof of the existence of the contracts, the amount of material required thereon, and satisfactory assurance that shipments would be utilized solely for the purposes of Government. While the question of perishability of certain products was discussed, it was the sense of the meeting that the present policy of leaving the decision in such cases to the Bureau of Chemistry, Department of Agriculture, should be continued.

The Department of Commerce in cooperation with the Department of Agriculture has long been earnestly striving to increase the output of tin cans for food containers. To this end it has endeavored to

increase the supply of tin, to secure the continuous movement of the materials entering into tin cans from the place of production to the place of use, and to facilitate the supply and movement of machinery for producing cans. The department desires in every practicable way to promote the present and permanent prosperity of the tin-can industry. There is no possibility of doubt of the steady and growing demand for its products.

Tin plate is 98 per cent steel and 2 per cent tin. Steel is the backbone of war, and the mills have been unable to keep up their customers fully supplied at all times. Moreover, abnormal freight demands have made prompt deliveries uncertain. There have also been decreased imports of pig tin, due to decreased production and reduced shipping facilities. It is not surprising, therefore, that the tin-plate makers cannot provide the can manufacturers with sufficient plate to enable them to meet the increase in the demand for cans, which is 25 to 40 per cent greater than it was last year.

It is therefore imperative that the available supply of cans be utilized, in so far as possible, for packing products that can be preserved only in tin, and that substitutes be used for other products wherever practicable. Such substitutes should be cheaper than tin, so that the ultimate benefit from lower costs may offset the initial expense of the substitution.

The price of glass has steadily risen and has reached a point which is a large percentage of its use for food containers is impracticable. At present fiber or paper containers of good quality are being produced in considerable quantities and increasing quantities for food purposes are supplanting glass and tin plate. The price of the fiber containers depends upon the size, the quality of the paper-pulp material, the number of printed covers, the paraffin, and the amount of printed matter on the outside. The commoner types may be obtained at 1.25 to 1.5 cents for the half-pint size, 1.25 to 1.5 cents for the quart size, and 1.5 to 1.65 cents for the quart size. Fiber containers are made in various shapes and sizes adapted to different purposes and may be made to be coated with paraffin, which is chemically inert and is sometimes baked into the paper material. Some of these containers are claimed to be air-tight, proof against leakage, and protected from contamination by the paraffin. Some containers appear to be more nearly air-tight than others of the same size, probably because of better fitting covers. The containers are light weight, pack readily for shipment, are easily opened, and are used but once.

The demand for "ready-to-eat" foods, such as baked pork and beans, spaghetti, and other containers for "heat and serve," represents the largest factor in the increased use of tin cans. These foods must be processed in the containers at about the temperature of boiling water, and a substitute for tin has been found that satisfactorily meets these conditions. However, a great economy in tin can be effected by home cooking of such products during the present shortage.

Fiber containers are recommended for the distribution by the retailer of many foodstuffs, including milk, cream, butter, milk, ice cream, syrups, marshmallows, cream, dried fruits, preserves, jellies, mince meat, horseradish, relishes, pickles, deviled ham and chicken, vinegar, dry and prepared mustard, soda water, soups, sauces, and preserves.

It is claimed that dry food products such as coffee, tea, alum, baking powder, spices, raisins and prunes may be successfully packed by producers and manufacturers in paper or fiber containers. These articles are in these products, bags lined with tinfoil have been in successful use for 10 years or more and they form an attractive package that is said to be moisture proof.

Other commodities usually packed in tin could be marketed as well in paper or fiber, with the advantage of lower cost. Among these tobacco occupies a conspicuous position, and other articles are tobacco, cigars, soap, powders, shoe polishes, metal polishes, soaps and shaving preparations, toilet articles, such as talcum powder, and various dry drugs and chemicals. Fiber containers are also suggested for preserved fruits and jellies made at home. Cloth sacks for tobacco and wood for syrups and molasses are also recommended where retail sales can be made in bulk.

For packers of dry products who are opposed to the adoption of fiber containers because of the good-will built up upon the style and shape of a tin container, fiber containers having the style and bottom of the tin container are available. These containers, when labeled, have the appearance of all-tin cans and are almost as serviceable.

Certain types of these containers are now being tested to determine to what extent the claims of their manufacturers as to their general qualities can be substantiated. Manufacturers of substitute containers who wish their products tested should send samples to the Bureau of Standards, Department of Commerce, with full information regarding commodities for which the containers are specially designed, prices and ability to contract for early deliveries. Names and addresses of firms prepared to supply fiber and paper containers may be obtained from the Bureau of Foreign and Domestic Commerce or its district or co-operative offices. Co-operation is required between the Government and the manufacturers of tin plate and of substitute containers, the packers of foodstuffs, and of other articles commonly put up in tin, and the general public, if the available supply of tin plate is to be limited to strictly necessary uses and if, at the same time, the largest possible quantity of food is to be preserved against the special needs of the coming months.

BEEHIVE COKE PRODUCTION IN 1916. The production of beehive coke in 1916 was never recorded in the United States, and the average value per ton was higher than in any previous year. The official figures for 1916, published by the United States Geological Survey, show that 35,464,224 tons of beehive coke, valued at \$95,468,127, were produced last year. The output in 1916 represented an increase over 1915 of 15 per cent or 23 per cent in quantity and \$38,522,584, or nearly 63 per cent, in value. The average value per ton of the coal used in making beehive coke in 1916 was \$1.34, an increase of 21 cents over 1915. The average value of the coke was \$2.69, an increase of 62 cents, or 30 per cent. The number of active beehive ovens in 1916 was 65,605, an advance from 1915 of 1,400, or 2.1 per cent. The number of idle ovens was 25,976, as against 44,125 in 1915. Abandoned ovens numbered 2265, of which 1,000 were in Pennsylvania and West Virginia. No new establishments and but 104 new beehive ovens at old works were reported to be under construction at the end of 1916, less than at the end of the recent years, especially in view of the high prices and steady demand for coke throughout the year. The coke producers evidently recognize the fact that the day of the beehive oven is passing and that after the present abnormal condition is over most coke will be made in by-product ovens. The official figures showing the production of coke in by-product ovens in 1916 have not yet been compiled.

INDUSTRIAL SITES ASSOCIATION.—The Industrial Sites Association of America, 115 Broadway, New York, has been organized for compiling and classifying data concerning the properties, sites, buildings, roads, bridges, water facilities, labor conditions, population, etc., of all towns and places where manufacturing plants could be advantageously established—a clearing house for information. The association works with complete and verified information free of charge. There are in many parts of the United States any number of cities and towns possessing many superior facilities and natural resources, admirably suited for manufacturing and other industrial purposes. Scarcely of desirable locations is no part of the manufacturers' problem. Their great lack has been a central source of information which would enable them to put their fingers on just what they wanted without traveling from city to city and making the expensive thousands of dollars and months of valuable time in a fruitless search for factory sites measuring up to their requirements. The officers are E. J. Briggs, president, and D. F. Smith, vice president, and A. M. Gerow, secretary-treasurer.

LOUISVILLE INDUSTRIAL FOUNDATION.—Louisville, Ky., has formed a million-dollar industrial bureau to assist industrial enterprise of all kinds in that locality. The Foundation has offices in the Commerce Building. The Foundation will render financial assistance to worthy industrial enterprises within the limitations and on the basis of the following conditions in the charter provision: The Foundation shall not invest more than 10 per cent of its capital in any one concern, nor shall it subscribe more than 33 per cent of the total capital paid, the capitalization of any one concern; and in considering capitalization, patents, franchises, sales rights, good will and similar items shall not be included. The financial assistance offered by the Foundation is not tendered as an inducement, but rather to provide additional working capital and to that extent assure the success of these manufacturers who have selected Louisville as a location because of economic advantages available there.

URGES TRADE AND COMMERCIAL ORGANIZATIONS TO CONTINUE MEETINGS.—President William Fellows Morgan of the Merchants' Association of New York has addressed a letter to President Wilson on behalf of the Merchants' Association, asking him to discourage the postponement of conventions. Mr. Morgan's letter is as follows:

"It has come to the attention of the Merchants' Association of New York that there is a tendency to forego the holding of conventions and general commercial meetings by business interests of the country because of a desire to practice alleged economy during the war."

"In our judgment this is a false idea of economy, the application of which will be harmful, rather than beneficial, both to the Government and to the Nation's business. Such gatherings, in our judgment, should be encouraged rather than discouraged, because failure to hold them as usual is likely to create a false impression, to stimulate a lack of business confidence and to discourage mutual co-operation which is so necessary under existing circumstances. Conventions and gatherings of different trades and industries afford an exceptional opportunity on the part of business men composing them to study the effect of the war situation upon industries, so that they may be best equipped to serve the needs of the Government and to secure the normal business of the country. Both business and general conventions also afford exceptional opportunities for patriotic gatherings and the fostering of patriotic sentiment."

"We therefore respectfully suggest that, if in your judgment the continuation of such meetings is beneficial, a public utterance by you to that effect would be of great value and would have a beneficial influence both in stimulating such gatherings and in perpetuating the results flowing therefrom. It seems to us that if ever the citizens of this country should meet together in business or general organization meetings, it is during such a period as that through which we are now passing."

Manufacturers' Catalogs

THE DRIVER-HARRIS COMPANY, Harrison, N. J., has issued a new bulletin form of catalog covering its line of products, with the exception of resistance materials, which are covered in its regular resistance catalog. These new bulletins include Monel metal, pure nickel, brass, heater cord, cold chisel, steel strip, brass, bronze and phosphor bronze wire and "Nichrome" castings.

THE CHALLENGE COMPANY, Batavia, Ill., has issued catalog No. 68, describing wood and steel tanks for all purposes.

THE DE LAVAL STEAM TURBINE CO., Trenton, N. J., has issued a booklet on "Progress in Water Works Pumps."

THE LINK-BELT COMPANY, Chicago, Ill., has issued a Book for 1909-1917, describing the ideal drive for grain elevators.

THE NASH ENGINEERING COMPANY, South Norwalk, Conn., has issued Bulletin No. 7, June 1, 1917, describing hydro-turbine air compressors and vacuum pumps, single-stage type.

THE DURIRON CASTINGS COMPANY, Dayton, Ohio, has issued Bulletin No. 100, April, 1917, describing standard pipe, drainage pipe, fittings, valves, cocks.

THE SMITH AND HUGHES ENGINEERING COMPANY, Lexington, Ohio, has issued an attractive booklet, Catalog No. 10, describing its type "MB" gas producer plants for delivering cold, clean gas from bituminous coal, reported as being for 1909-1917. It describes charcoal and lignite for power and fuel purposes.

Other New Publications

TEMPERATURE MEASUREMENTS IN BESSEMER AND OPEN-HEARTH PRACTICE. By George K. Burgess. A Department of Commerce publication, No. 91, issued May 8, 1917, by the Bureau of Standards, Washington, D. C.

INDUSTRIAL AND CHEMICAL ENGINEERS is the title of a booklet issued by the Will Corporation, Rochester, N. Y.

THE EMBODIMENT ACTION OF SODIUM HYDROXIDE ON STEEL. By S. W. Parr. Bulletin No. 94, published by the University of Illinois, Urbana, Ill., at the Engineering Experiment Station.

REPORT ON THE BRET SUGAR INDUSTRY IN THE UNITED STATES. This report was issued on May 27, 1917, by the Federal Trade Commission, Washington, D. C.





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